

NLGI

Spokesman

Journal of National Lubricating Grease Institute



the case of

the cost-cutting grease formula

and how Mallinckrodt made 3 lbs. of soap do the work of 4

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assure you maximum benefit from
Witco quality products...

1. *Prompt, courteous, dependable service, from seven sales offices throughout the United States.*

2. *Complete technical service—from WITCO's Technical Service Laboratory at Chicago, Ill., where the most modern testing equipment is available for evaluation of the properties of greases under all conditions encountered in their application. Also the effect of various raw materials on the properties of the finished product can be predetermined.*

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machines that work for machines

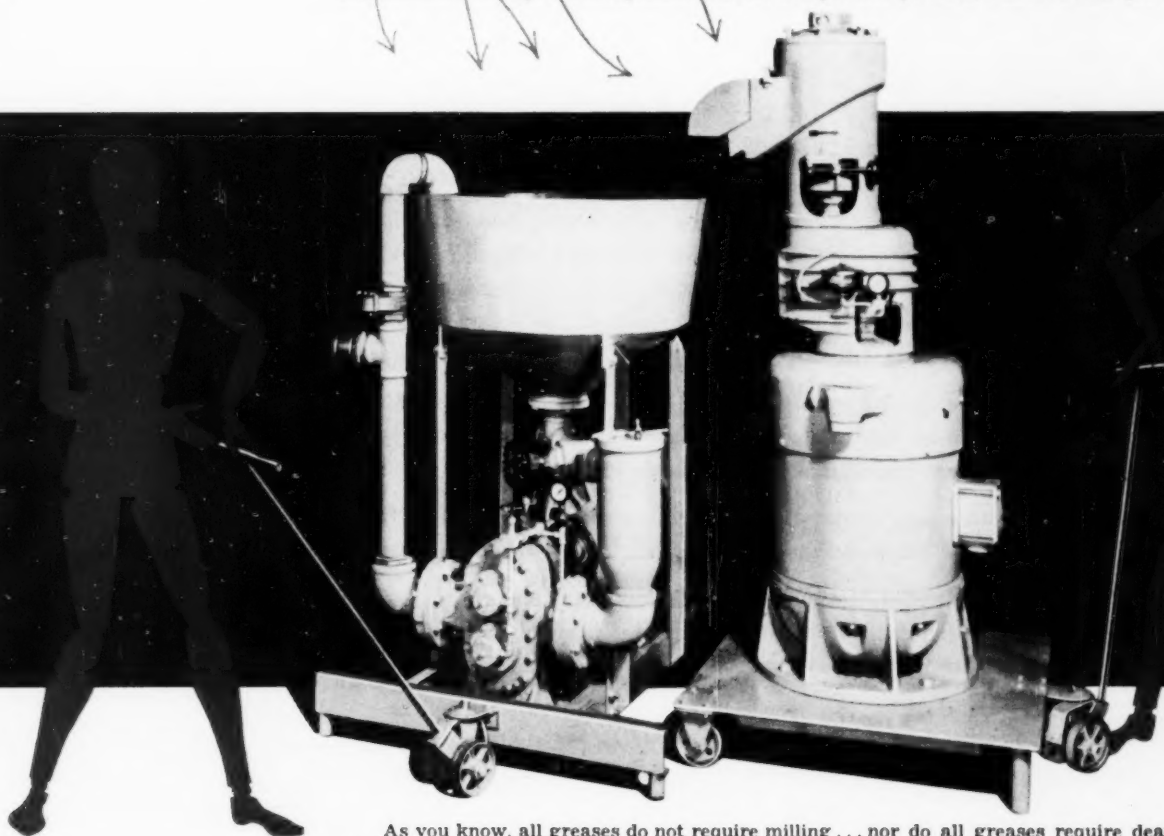
We usually think of machines as working for men, and ultimately, of course, they all do. But many, many machines exist only to work for other machines. You'll frequently find a machine that makes or processes component parts or materials for another machine... or, provides the motive power for another machine... or, controls another machine.

In the case of the Morehouse Mill, we find a machine that is in the unique position of helping *all* other machines... by participating in the production of the many standard and specialized greases needed to keep those other machines operating efficiently and effectively.

Today, greases of many types are being made with better uniformity, greater homogeneity, and higher quality because they are processed, in one or more stages of their production, on Morehouse Mills.

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The Morehouse Mill and grease deaerating equipment illustrated produces up to 25,000 lbs. of high quality grease per hour. Each unit independent, portable. Note casters and tow attachment. Portable and non-portable units of lower capacity are also available.

As you know, all greases do not require milling... nor do all greases require deaerating. However, a grease frequently will require one and not the other... or it may require both. That is why Morehouse Mills are available separately or in combination (no plumbing required) with Morehouse deaerating equipment. All equipment can be made portable.

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on Grease Processing
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Indication of Leadership**



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President's page

by G. A. OLSEN, President, NLGI

A THANKSGIVING PRAYER



During November, we observe two Holidays, each of which is significant of our democratic way of life. On Armistice Day, we commemorate the valiant veterans who gave their all during World War I that the democratic way of life might not perish from this earth and that war would be no more.

Since our first Armistice Day, power-greedy people have nullified the hope of no more war but we have great cause for Thanksgiving that they have, so far, been unable to destroy the democratic way of life which has been preserved for us to enjoy.

In Thanksgiving, therefore, let us dedicate with determination our future for the preservation of all the blessings we enjoy as a result of the unusual foresight of our Founding Fathers, and join in the following prayer by General MacArthur:

"Build me a son, O Lord, who will be strong enough to know when he is weak, and brave enough to face himself when he is afraid; one who will be proud and unbending in honest defeat, and humble and gentle in victory.

"Build me a son whose wishbone will not be where his backbone should be; a son who will know Thee—and that to know himself is the foundation stone of all knowledge.

"Lead him, I pray, not in the path of ease and comfort, but under the stress and spur of difficulties and challenge. Here let him learn to stand up in the storm; here let him learn compassion for those who fall.

"Build me a son whose heart will be clear, whose goal will be high; a son who will master himself before he seeks to master other men; who will learn to laugh; yet never forget how to weep; one who will reach into the future, yet never forget the past.

"And after all these things are his, add, I pray, enough of a sense of humor, so that he may always be serious, yet never take himself too seriously. Give him humility, so that he may always remember the simplicity of true greatness, the open mind of true wisdom, the weakness of true strength.

"Then, I, his father, will dare to whisper, 'I have not lived in vain.'"

May each one of us endeavor to emulate this prayer in our day-to-day living, and thereby add our daily bit in preserving this great democratic heritage.

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Harry F. Bennetts, Editor
Joanne Couey, Assistant Editor
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Kansas City 12, Mo.

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OFFICERS

President: G. A. OLSEN, Sunland Refining Corporation, P. O. Box 1512, Fresno, Calif.
Vice-President: H. L. HEMMINGWAY, The Pure Oil Company, 35 E. Wacker Drive, Chicago, Ill.
Treasurer: A. J. DANIEL, Battenfeld Grease and Oil Corp., 3148 Roanoke Road, Kansas City, Mo.
Executive Secretary: HARRY F. BENNETTS, 4638 J. C. Nichols Pkwy., Kansas City, Mo.

DIRECTORS

W. W. ALBRIGHT, Standard Oil Company (Indiana), 910 S. Michigan, Chicago, Ill.
M. R. BOWER, Standard Oil Company of Ohio, Midland Bldg., Cleveland 15, Ohio.
R. CUBICCIOTTI, L. Sonneborn Sons, Inc., 300 Fourth Avenue, New York, N.Y.
A. J. DANIEL, Battenfeld Grease and Oil Corp., 3148 Roanoke Rd., Kansas City, Mo.
R. W. GOODALE, Standard Oil Company of California, 225 Bush Street, San Francisco, Calif.
H. L. HEMMINGWAY, The Pure Oil Company, 35 E. Wacker Drive, Chicago, Ill.
H. P. HOBART, Gulf Oil Company, Gulf Building, Pittsburgh, Pa.
C. L. JOHNSON, Jesco Lubricants Company, P. O. Box 7331, North Kansas City, Mo.
C. B. KARNS, Esso Standard Oil Company, 34th and Smallman, Pittsburgh, Pa.
J. W. LANE, Socony-Vacuum Oil Company, Inc., 26 Broadway, New York 4, N. Y.
H. A. MAYOR, JR., Southwest Grease and Oil Co., 220 W. Waterman, Wichita, Kans.
G. E. MERKLE, Fiske Brothers Refining Co., 129 Lockwood Avenue, Newark 5, N. J.
W. M. MURRAY, Deep Rock Oil Corporation, P. O. Box 1051, Tulsa 2, Okla.
G. A. OLSEN, Sunland Refining Corporation, P. O. Box 1512, Fresno, Calif.
F. E. ROSENSTIEHL, The Texas Company, 135 East 42nd Street, New York 20, N. Y.
W. H. SAUNDERS, JR., International Lubricant Corporation, New Orleans, La.
H. B. STONE, Atlantic Refining Company, 260 S. Broad Street, Philadelphia 1, Pa.
B. G. SYMON, Shell Oil Company, Inc., 50 West 50th, New York 20, N. Y.

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ABOUT THE COVER

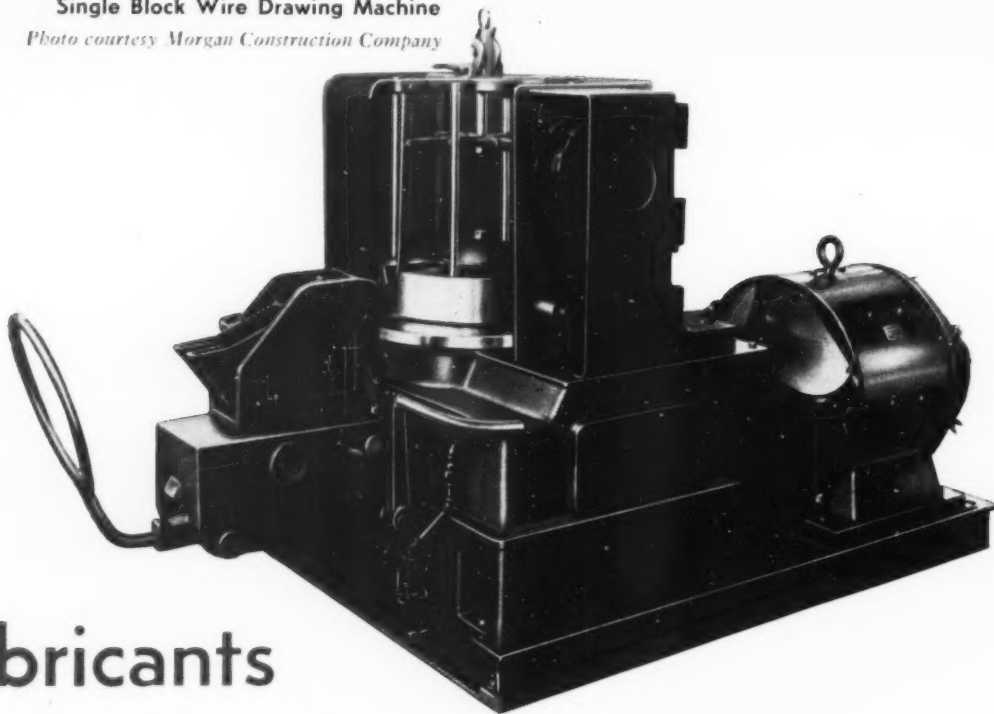
THE 21ST PRESIDENT of the National Lubricating Grease Institute, whose picture appears on the front cover of this month's *Spokesman*, is G. A. (Fred) Olsen, whose election was announced at the annual meeting in Chicago, October 26-28.

Mr. Olsen moved from Colorado to California at an early age and, upon receiving his discharge from the Army at the close of the first World War, entered the employ of Union Oil Company of California, leaving it in 1923 to become a co-founder of Sunland Refining Corporation, of which he has been the president since 1948.

For years, he has maintained a keen interest in this Institute and kindred organizations. He is a member of the Lubrication Committee of the American Petroleum Institute, a past director of the Independent Refiners Association of California, a director of the Fresno City and County Chamber of Commerce, past president of the Fresno Optimist Club, a member of the Society of Automotive Engineers, American Society of Lubrication Engineers, American Oil Chemists Society, California State Disaster Council's Petroleum Industry-Civil Defense Advisory Committee, and other civic and social clubs.

Fred, as his friends call him, is married, lives in Fresno, Calif., and has a daughter, two sons, and five grandchildren.

Single Block Wire Drawing Machine
Photo courtesy Morgan Construction Company



Lubricants for Drawing Metals

By Allen A. Brown
Reilly-Whiteman-Walton Co.
Conshohocken, Pennsylvania

As with most things in our experience, it is of prime importance, when considering drawing lubricants, to get down to fundamentals. The fundamentals are well known but, unfortunately, often lost sight of, when we are confronted with a drawing lubricant problem. Hence, with the full realization that we will be repeating things that have been well covered in the past, and available in the literature, let us first discuss drawing operations in general. Then, we propose to cover some of the fundamental requirements of lubricants for drawing metals. And finally, we will give particular emphasis to the extremely important role played by the fatty oils and their derivatives, as drawing lubricants, or as components of such lubricants.

Number one fundamental to keep in mind, in this discussion, is the nature of the thing with which we are working. Practically all metals are crystalline in nature, and their surfaces are not perfectly smooth. Even the finest finishing operations will leave jagged edges, fragmented crystals, hills and valleys. These surfaces are not chemically clean, and they have coatings of oxides, water vapor, and chemical compounds resulting from pickling, cleaning, or other processing operations. Num-

ber one, then, is that we are not dealing with a clean smooth surface; it is contaminated, and it is rough.

The second important thing is to remember that unit pressures are high. They have to be, as the forces *must* be such as to exceed the yield strength of the metal, whenever we are actually *drawing* metal, by means of forcing or pulling it through a die. These forces are exerted over a much, much smaller area than casual observation might indicate. Even with very heavily loaded surfaces, with all the surface irregularities, hills, and valleys flattened, probably the entire load is carried by no more than two or three per cent of the apparent area. The forces have to be high, the unit pressures high, very high—that is the second thing to keep in mind.

These forces, applied to the work piece in drawing, result in motion within the metal being formed, and in the sliding of the work piece surface across the die. It is no longer believed that the friction, resulting from the sliding motion of the metal being drawn through the die, is the result of the interlocking of the hills and valleys of the metal surfaces in sliding contact; rather, it is felt that this friction is the result of intermolecular attraction between portions of the two surfaces, in close proximity. These forces are very large, and result in *welding* of limited areas of the two surfaces. The *third* thing to keep in mind, then, is that welding of the high spots is occurring, and it is the forces involved in mak-

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ing and breaking these welds that account for the large portion of surface frictional resistance in drawing operations.

As these welds are made and broken, "sticking" and "slipping" occurs, but so rapidly, in most cases, that it cannot be observed. Even with "well lubricated" drawing operations, this welding probably occurs to a greater extent than is realized; if lubrication fails, the tiny welds increase in size until they are large enough to be seen by the naked eye. We then say that "scratching" has occurred.

The prime purpose of a drawing lubricant, therefore, is simply to prevent this welding of the surface high points during sliding contact. There are many other auxiliary requirements, for a good drawing lubricant, but this is its basic purpose. Once this purpose is accomplished, it is then possible to turn to the matter of the internal friction of the lubricant itself.

The frictional resistance, which can be affected by a choice of drawing lubricants, is that due to welding and also that due to the resistance to stress deformation of the lubricant itself. If we include, in this discussion of drawing lubricants, the wide variety of metallic coatings, fillers, pigments, reactive materials, as well as the unctuous substances (which usually come to mind when we think of a "lubricant"), it will be realized that the internal friction of the lubricant can be excessive. However, the cold working of metals of high yield strength usually requires a degree of weld prevention which cannot be obtained from unctuous lubricants alone.

Nor is it always desirable to reduce the surface friction to a minimum, in a drawing operation. The improper flow of metal, as in a deep drawing operation where wrinkling occurs, can often be corrected by using a drawing compound having a higher internal friction.

It may be easier to think of the basic weld prevention function, as that of separation, and of the internal lubricant friction as the degree of slip. Metallic coatings, fillers, pigments, and the like, provide a lot of separation and very little slip. Fluid oils, on the other hand, do not have comparable separating ability, but do have

very low internal friction. In most drawing compounds, an attempt is made to combine adequate separating ability with an optimum amount of slip for the particular application. This does not mean, necessarily, that it is always possible to combine these properties in a single compound; it may be better to apply the separating phase as a coating, firmly bonded to the work piece, and follow this with the application of the slip producing phase.

The terms "fluid film lubrication" and "boundary lubrication" are often used in describing lubricants, and it might be well to differentiate between these before proceeding further. In most bearing lubrication, the unit pressures are relatively low, and non-polar, non-reactive lubricants, such as mineral oils, will maintain a relatively thick lubricant film. The pressures are not high enough to squeeze the metal surface together, and no welding takes place. Very low frictional coefficients (in the order of 0.005) are observed. If proper attention is paid to bearing design, clearances, oil application, and the like, wear of the bearings is virtually absent. Fluid film lubrication conditions do not prevail in cold working operations, and fluid film lubricants have little or no value as metal working lubricants.

Boundary lubrication is the term that is used to describe the conditions which exist when it is not possible to obtain fluid film lubrication; that is, when unit pressures are high, as in a drawing operation. Frictional coefficients are high (0.02-0.10) and the hydrodynamic laws used for fluid lubricants no longer apply. Lubricants of a far different type than those used in fluid lubrication must be considered.

Since weld prevention, or the separation of the work piece from the tool is the basic requirement, we should first consider the various means now used to accomplish this end. Coatings of ductile metals, such as lead, copper, tin, and zinc, probably provide the maximum in separating ability; unfortunately, they also entail the greatest expense and handling difficulties. The growing use of phosphate coatings (primarily zinc phosphate) may be attributed to the somewhat greater ease of application combined with excellent separating ability.

Six Draft Morgan-Connor Continuous Wire Drawing Machine

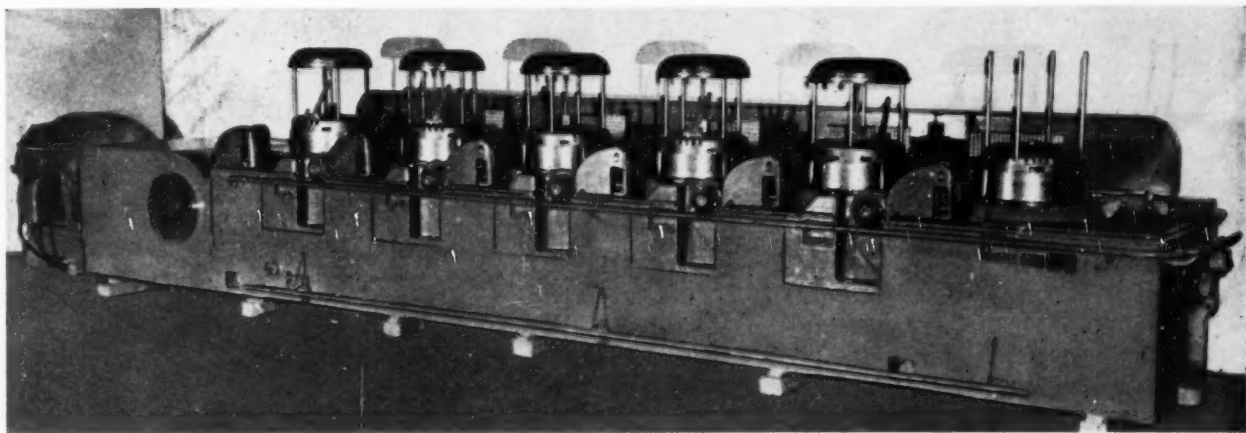


Photo courtesy Morgan Construction Company

Sulphide and oxalate coatings are employed on metals which will not "take" a phosphate coating. Borax, lime, and rust (sulf coating) are in everyday use, as is well known. With all of these coatings, it is necessary to use a separately applied slip producing phase, and the surface friction is relatively high because of the necessity of deforming the coating.

When no coating is applied intentionally, there still exists on the work piece surface a film of oxide and water vapor. Without this film, the forming of "bare" metal, by use of conventional drawing lubricants, would be a far different problem, and it is unfortunate that more attention has not been paid to this aspect of the problem. When a drawing lubricant is applied to such a "bare" metal surface, without a separately applied coating, weld prevention is accomplished by both the surface contaminants and the drawing compound itself. There are many, many applications where a separately applied coating is the best answer to a difficult lubrication problem; at the same time, there are applications where the expense of a separately applied coating could be saved if more attention would be paid to surface preparation of the work to be processed.

Drawing lubricants which are used as the slip producing phase over coatings do not differ greatly from those which are directly applied to "bare" metal. When no coating is present, it is often necessary to build increased separation into the drawing compound, by the use of pigments or reactive elements; except for noting this, no further distinction will be made.

The vast number of drawing compounds available to industry, in addition to a large number of mixtures made by operating personnel, indicates that there are considerations other than those already mentioned. Indeed, these secondary requirements usually dictate the choice of a particular lubricant for the application. Weld prevention and lubricant friction having been established to the point of obtaining scratch free work, with satisfactory tool life and a minimum number of passes (when multiple drafting is required), the major secondary considerations are: application, stability, corrosion, removal, economy, and both physiological and psychological effect on personnel.

The method of application is often dictated by the type of work. For instance, it is not practical to swab a drawing compound on the inside surface of a tube, and application must be by immersion, or by circulation at the draw bench. In the case of forming an automobile fender, the compound is "spotted" in order to secure satisfactory flow of the metal. Compounds which will work with one method of application may fail if applied by another. In general, the longer the time interval between application of the compound and the drawing operation, the better will be the results obtained. When the compound is expected to give maximum separation, and is applied from an emulsion or water dispersion, forced drying of the water from the compound may make the difference between success

and failure. Concentration of water dispersible compounds is very important, and it is not unusual to find that leaner dispersions will work better than more costly, richer mixes.

Stability of the compound usually is a problem only with those products intended for use as emulsions. The emulsion may be too unstable for a particular operation; or it may be too stable. If it is unstable, very uneven application results, with large quantities of lubricant being applied to certain areas or certain pieces, coupled with little or no lubricant on other areas or pieces. Lubricants which are too stable, where the lubricant is hard to take out of the water used the diluent, usually provide insufficient lubrication. With a given compound, the stability is affected by water hardness, temperature of application, aging of the emulsion, and contamination—usually from acid residues of prior operations. Lubricants which contain fillers or pigments must be agitated constantly in order to prevent sedimentation of the pigment, unless they are used so concentrated as to prevent sedimentation of the pigment by high viscosity of the compound.

Corrosion of work, or equipment, can be caused by improper selection of drawing compounds. This can be extremely severe with some compounds if annealing is done without prior cleaning. Reactive elements, such as sulphur and chlorine, on one form or another, are excellent weld preventives, and are used in a great many compounds intended for difficult work. Highly alkaline products may be just the thing for some jobs, but not for a galvanized surface.

The removal of a metal working lubricant can cause all kinds of trouble, or it may be accomplished with ease. The very products and procedures which may give the best separation of the work piece from the tool are the ones which may offer the greatest resistance to cleaning. Compounds containing fillers and pigments are bad offenders, as these are pressed into the metal; in some cases they can be removed only by abrasion.

True economy involves a great many considerations other than the price per pound of a given product. While high cost of a lubricant is no guarantee of an optimum balance of desired characteristics for an operation, it is obvious, likewise, that the lubricant pennies can be held so close to the eye as to prevent seeing the production dollars.

Of all the physiological and psychological complaints received by plant management pertaining to drawing compounds, two stand out. Industrial dermatitis can be caused by some types of lubricants, or by contaminated lubricants, and requires close attention by both suppliers and users. Bad odors may not be detrimental to health, but certainly do not make for pleasant working conditions. Products made from high quality raw materials, and which contain proper preservatives and germicides, are the best answers to these problems.

To comply with all of these requirements, plus a few more not discussed, usually involves a fairly complex job on the part of the compound manufacturer. There is very little standardization of metal processing lubricants, as it usually is the lubricant which is tailored for

glycerides for

- lubricating greases
- textile finishes
- protective coatings
- cosmetics
- pharmaceuticals
- candles
- leather dressings, etc.

CENWAX G (hydrogenated castor oil)

CENWAX G is a glyceride chemically, although physically it resembles a wax. It is a hard, high melting point solid, available in finely beaded form, with practically no taste or odor. Typical applications are in lithium, barium or sodium greases; hot-melt paper coatings; extender for higher priced waxes in polishes. These CENWAX G specifications should suggest other uses:

F.F.A. (as Oleic Acid)	.....2.0 max.
Acid Number	.....4.0
Saponification Number	.....176-184
Iodine Value (WIJS)	.....1-5
Melting Point (°C)	.....82-85
Hydroxyl Value	.....155-165
Acetyl Value	.....137-148

CENTURY HYDREX 360 (hydrogenated tallow glyceride)

This hardened tallow product is available in beads and its good color, high titre and low iodine value particularly suit it for use in certain textile finishes and lubricating greases.

SPECIFICATIONS

Titre	.....(136.4-140.0°F) 58-60.0°C
Iodine Value (WIJS)	.....1-3
Free Fatty Acid	.....1-3%
Acid Number	.....2-6
Saponification Value	.....190-195
Color 5¼" Lovibond Column(Max.)	15 Yellow-2 Red

W. C. HARDESTY CO., Inc.
Century Stearic Acid Products, Inc.

41 EAST 42ND STREET, NEW YORK 17, N. Y.

PLANT: DOVER, OHIO

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Figure 1—Table gives chemical characteristics and fatty acid composition for the more important natural oils and fats as well as chemical data for waxes.

There is one thing that is common to practically all good metal processing lubricants—they contain products derived from the natural fats, by simple refinement or by more involved processing. An understanding of

On Figure 2 are found the structural formulas for several fatty acids. Those which are most familiar,

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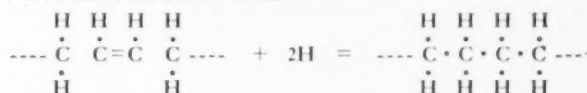
stearic acid and oleic acid, are present in one form or another, in most good metal processing lubricants. These fatty acids consist of long hydrocarbon chains which terminate in a carboxyl group, or the "business" end of the molecule. The unsaturated fatty acids are missing one or more hydrogens.

It was said that the fats occur naturally as *mixed* esters. In some applications, a high degree of purity is desired. On the top of Figure 4 is shown the result of reesterification—in this case, the combination of oleic acid with glycerine to form glycerol tri-oleate. Other alcohols may be used to obtain different esters of desired characteristics. In the presence of water, the process is reversed, and the fatty acid obtained from the ester by hydrolysis. At the bottom of Figure 4 is found

All of these things have a bearing on the functioning of the fatty lubricant. Of utmost importance is the fact, first proven by the classic research of Langmuir, that the fatty acids orient themselves with the carboxyl group (the active end of the molecule) at the surface. This results in the formation, on the tool and work piece, of a film of fatty acid molecules which stand up from the surface, much like the pile of a carpet. The bond between the active end of the fatty acid molecule and the metal is a very tenacious one; the long hydrocarbon chain sticking up from the surface is the separator that reduces the tendency towards welding, hence the longer this chain, the better. These layers of fatty acid molecules build up, on the surface, to a considerable thickness—several hundred molecules thick. While there is a tenacious bond to the metal, which gives a good separation, the long hydrocarbon chains lack attraction for each other, and this results in low lubricant friction, or a high degree of slip.

The fatty esters, which may be present along with the fatty acids, have a polar nature, and behave in a

Hydrogen reacts with liquid unsaturated fats at high temperatures in the presence of a nickel catalyst to form solid saturated fats. The hydrogen eliminates unsaturation by combining with the carbon atoms at the double bond.



Unsaturated oils may be oxidized and polymerized by blowing with air at elevated temperatures, or by the natural drying of these oils in thin films. The examples represent some of the many complex changes which may occur at points of unsaturation.



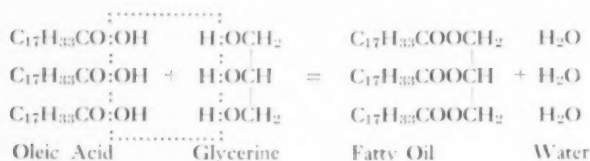
Hydroxy-Ketone



Figure 3—Unsaturated fatty acids can be made saturated by hydrogenation or changed through oxidation.

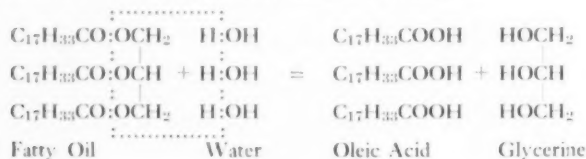
ESTERIFICATION

Three molecules of fatty acid combine at high temperatures with one of glycerine to form a fatty oil (glycerine ester) and water. The water must be removed as formed in order for this reaction to proceed.



HYDROLYSIS

A molecule of fatty oil may slowly decompose (hydrolyse) in the presence of water to form fatty acids and glycerine.



SAPONIFICATION

Fatty oils react (saponify) with caustic alkalis to yield soap and glycerine.

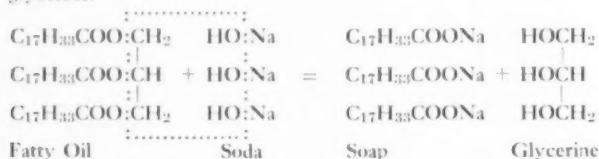


Figure 4—Changes in the molecule through esterification, hydrolysis, or saponification are illustrated in this diagram.

somewhat similar manner. In addition to this, the esters liberate fatty acids, serving as a reservoir to replace the acids consumed. Polymerization of the fat results in large molecules, with increased separating ability, and the higher internal friction of these polymers provides less slip in those applications where this is desirable. Removal of the fatty lubricant may be accomplished with ease, as the fats are soluble in degreasing solvents or saponify and emulsify readily in alkali cleaning baths.

When processed and applied properly, alone or in combination with other agents, a great deal can be done with fatty lubricants. For the past four years we have been supplying the steel industry with a perfectly satisfactory replacement for imported natural palm oil, made from domestic fats, uniform in its characteristics, and at a considerable saving in average cost. It is now possible to dip bare high carbon steel wire or rod in a fatty drawing lubricant, dry it, and draw it through six dies on a continuous bench at top speed, (about 1200 fpm). This is done without any soap or other lubricant applied at each individual die; wire quality and die life are at least as good as with the more conventional practice, and the lubricant cost is much less. The dry soap dust in the wire mill is eliminated. These are but two examples of improvements which can be made by co-operation with practical application of the fundamentals we have discussed.

Discussion

Presented by

ROBERT C. WILLIAMS, Director of Research, the Ironsides Co., Columbus, Ohio

ALLEN A. BROWN, Reilly-Whiteman-Walton Co., Conshohocken, Pennsylvania

E. L. H. BASTIAN, Senior Engineer, Shell Oil Co., New York, New York

WALTER A. SNIIGEL, General Manager, R. H. Miller Co., Homer, New York

HARRY N. DAVIS, R. H. Miller Co., Homer, New York

D. E. WHITEHEAD, General Lubricating Engineer, Crucible Steel Co. of America, Pittsburgh, Pennsylvania

H. E. MARTIN, District Sales Manager, E. F. Houghton Co., Philadelphia, Pennsylvania

JAMES McELGIN, Manager Metal Working Department, E. F. Houghton Co., Philadelphia, Pennsylvania

Robert C. Williams: Some years ago we found that you are not always working with what you think you are working with. You may have oxide films, and sometimes you cannot do much about those. In order to evaluate a lubricant, you may use a piece of metal which may have been sitting around in the mill for a while and it becomes contaminated from materials carried in the atmosphere, dust, fumes, various sorts of materials. You are not working with the metal. It became very apparent to us when we were running some friction experiments on wire drawing lubricants. We soon found that we had to chemically clean the wire before we performed any experiments, because the results were erratic, so we chemically cleaned them insofar as atmospheric contamination is concerned, and I found out a little more than we had before we started doing that.

Another point which I had hoped Mr. Brown might dwell upon a little more, is the use of wax lubricants, or waxy films. They are coming to the fore more and more. Possibly we started on that before we should have. We had trouble getting hearings and trials in the earlier days and found that wax, as Mr. Brown points out, is affected in its performance very much according to the temperature with which it is used.

It was very enlightening to us that, if we used a wax at a temperature above its melting point, that we gained very little over using an oil of a comparable viscosity at the temperature at which we used the wax. But, if we always had the drawing operation started initially at a temperature where your wax was a solid, we got an effect which we likened to skating on ice. The wax suddenly melted at the point of contact and friction was reduced very, very substantially. As a matter of fact, we did not believe what we were getting for a while.

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I would like to ask Mr. Brown if he has found anything similar to that.

Allen A. Brown: On mineral waxes I could understand very definitely that the material in the solid condition would offer a lot over the materials in the liquid condition. But our experience has been on fatty waxes that the heat of any operation has a tendency to dissociate the ester, to break away, or split away some of its fatty acid from the ester, and give the formation of metallic soaps, which have proven in our experience to give better lubrication than solid mineral waxes.

E. L. H. Bastian: In general, the fundamentals referred to are certainly applicable as discussed. However, it would be interesting to have Mr. Brown's views on the value of cooling as a primary function of the drawing lubricant.

While certainly we must agree that boundary lubrication is more important than fluid or hydrodynamic lubrication in metal drawing, it may be worthwhile here to mention the effects of viscosity in tube drawing applications. These have been noted practically by many shop men and experimenters alike. Mr. Brown's comments on this point would be appreciated.

He mentions the adverse effects of alkaline lubricants on zinc coated or galvanized work. The same comment should probably be extended to apply also to drawing of aluminum.

With regard to the classification of drawing lubricants as discussed by Mr. Brown, I would like to make a point here about those lubricants that ordinarily are considered boundary lubricants employed in drawing applications, breaking them down somewhat along this pattern. First of all, considering the polar compounds, as he pointed out, they have their effect by absorption on the metal surface and essentially function by a continual shearing through the asperite peaks on the roughness of the surfaces. The fatty acids, the fatty oils are typical of these purely polar compounds.

The second group of drawing lubricants which you might consider as another group or entity for classification purposes, would be the so-called "polishing agents." These polishing agents act over and above the simple effects of the polar compounds by chemical action on the metal surface. Typical of polishing agents would be tricresyl phosphate, for example, where a mild chemical action occurs to prevent excessive welding or tearing or rupture of the metal surface.

In the third group of drawing lubricants that might be classified as such, we consider the true extreme pressure lubricants, and there I have in mind the types of lubricants which act through rather drastic chemical action on the metal surface to form, for example, sulphide-chloride films in the case of sulphur-chloride compounds.

These three classifications do not necessarily all include the use of fatty oils, and, while the employment of fatty compounds, natural fats, and fatty acids in drawing lubricants is quite common, I believe it is fair to suggest that there may be other formulations which are as effective, or more effective, under certain conditions of drawing.

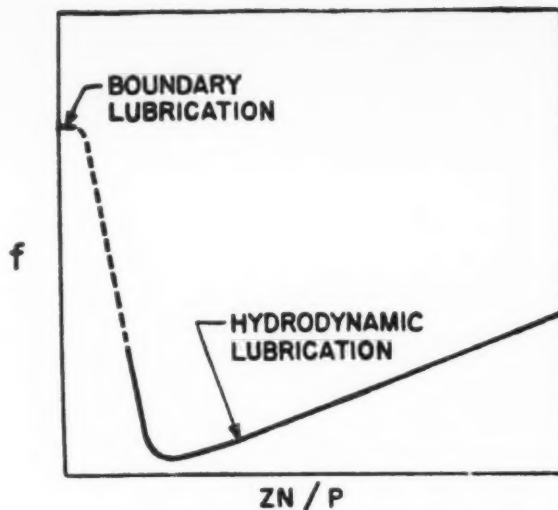


Figure 5—Curve shows that friction varies as a function of pressure, velocity, and viscosity.

I have several illustrations which more or less confirm some of the points Mr. Brown made on the subject of boundary lubrication.

Figure 5 shows the effects of friction as a function of pressure, velocity, and viscosity in the regions of boundary and hydrodynamic lubrication. The ratio here, ZN/P , is a ratio indicating the effects of, first of all, viscosity represented by Z , which is absolute viscosity, and N representing the speed of motion of the two surfaces in contact, which in the case of drawing, may be the die surface, or metal surface, and which is ordinarily represented in feet, and P representing the pressure between the two contacting surfaces in psi. The coefficient of friction is equal to this ratio times a constant to adjust for the units involved. The point that I think is of interest here in connection with Mr. Brown's discussion of modern lubricants is that in this range of hydrodynamic lubrication, the ratio holds. In other words, as viscosity increases, as speed increases, the coefficient of friction increases. As the pressure increases, the coefficient of friction decreases. Various experimenters have shown, there is a range, indicated by some as the quasi-hydrodynamic range of lubrication, wherein there is a transition in the usual relationships that occur in hydrodynamic lubrication. Some investigators indicate a condition of boundary lubrication where velocity becomes zero. In the work of investigators like Larsen and Vesper, by laboratory means the effect of metal pickup is indicated reflecting a condition of welding, where instantaneous welding and breaking of welds, as mentioned by Mr. Brown, occurs. The frictional coefficient remains constant during boundary lubrication for the reason the only condition that applies is a condition of the surface. As Mr. Brown pointed out, the condition of the surface is a very important indication of the degree of drawing lubrication.

Figure 6 is intended to indicate the results of some work with which some of you may be familiar, the use of the four ball type machine, wherein the coefficient of friction under various conditions of lubrication are

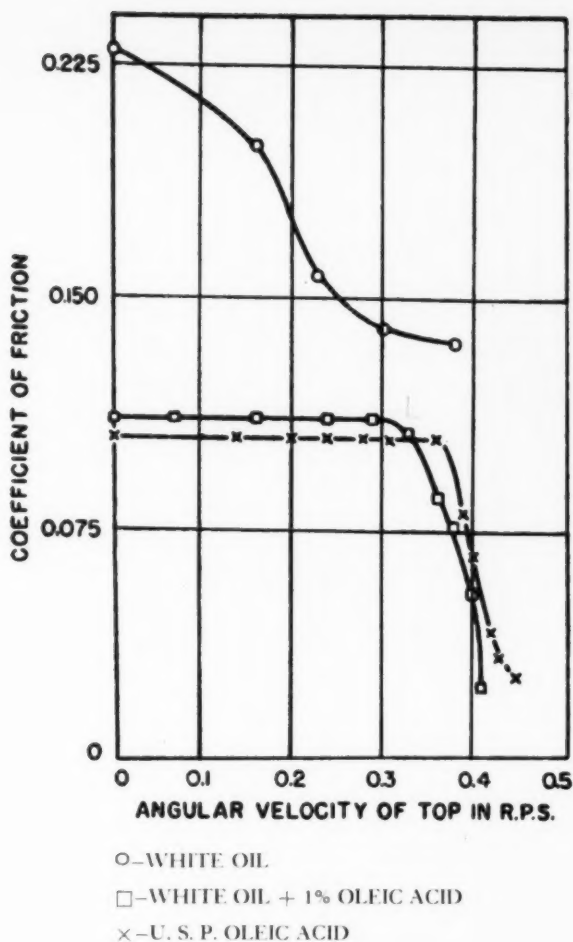


Figure 6—Friction is shown to be a function of the velocity in the four-ball top test.

given. Under given conditions of loading and with decreasing velocity of the spinning top, the coefficient of friction with various lubrication media changes as indicated by this chart. With a simple mineral oil such as refined white oil, the friction coefficient increases as the velocity decreases and goes up into the ranges as you see here. With the addition of even a small concentration of fatty acid, one per cent oleic acid, with decreasing velocity, the friction coefficient remains constant going down to zero velocity, indicating the boundary lubrication effects of the fatty acid. And with 100 per cent oleic acid, a typical fatty acid, the same phenomenon is observed.

Figure 7 indicates the condition of wear which occurs between two metal surfaces below the point of seizure, and shows a polishing action of one metal on another, but without actual seizure or tearing of the metal surface. This sort of condition would occur in drawing with the use of such lubricants as the polishing agents, for example.

Figure 8 shows the effect of metal pickup of soft metal on a harder metal surface and would be representative, for example, of the drawing of aluminum with steel die

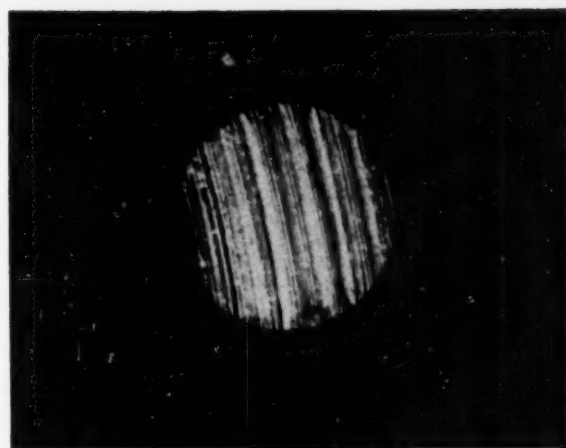
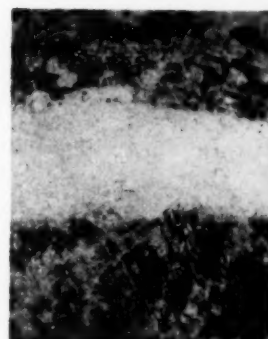
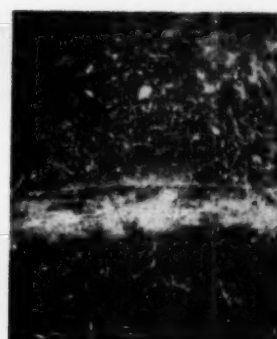


Figure 7—Photomicrograph shows wear scar on lower ball below the point of seizure in a two-hour test at a 15-kg load.

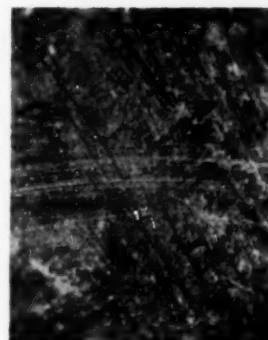
surfaces. It shows, in this case, the pickup of aluminum on the top steel ball of a four ball apparatus, the top ball being harder than the lower three balls, rotated under certain conditions of speed, and lubricated with various lubricants as captioned on the figure. The use of a natural wax, such as ceresin wax, plus a small amount of fatty acid, shows considerable improvement in minimizing the pickup.



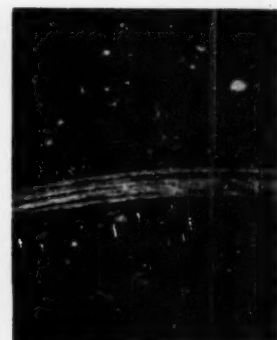
A. White Oil



B. Ceresin wax + 5% Oleic Acid



C. Palm Oil



D. Lard Oil

Figure 8—Metal pick-up studies. Photomicrographs of wear tracks are shown for steel vs. aluminum on upper balls of four-ball wear top.

The use of two commonly known and rather typical fatty oils which have pronounced boundary lubrication value, palm oil and lard oil, show even more diminished pickup of the soft metal on the hard metal surface.

Walter A. Smigel and Harry N. Davis: We would like to take the liberty to compliment Mr. Brown on his paper in which he has very ably expounded upon the theories and fundamentals of metal drawing lubricants. We were very interested in Mr. Brown's references to the lubricant coating applied to wire by dipping and drying, thereby eliminating die box lubricants.

A couple of years ago, Mr. Verner and I presented a paper "Metal Drawing Lubricants for Wire, Tubing and Sheet Metal Steel," 1951 Proceedings AISE, p 244 in which we stated that we had obtained very excellent drawing results using lubricant coatings. For example, low carbon rod was drawn as many as 12 holes. However, we felt that the process had limitations because of the usual mill variations. We nevertheless said at that time that we felt that this method warranted further research.

At the present time, we think we are considerably less enthusiastic about this process having made trials a number of times during a period of 20-some years. We think one reason for our feeling is that the process is not flexible. It would take a number of dip tanks to satisfy all the requirements for various wire finishes demanded by the wire trade.

Secondly, if the coating is destroyed during drawing for any reason, other than the efficiency of coating itself, and for reasons such as poor steel, irregular rods, worn dies, or the other many conditions that we find in everyday wire mill operation, if the coating is destroyed, it cannot be re-established as is usually the case with die box lubricants. We may be wrong, but we do not think that this type of process will substantially displace the regular die box lubricants for continuous drawing.

Allen A. Brown: I would like to give some of the data that we have procured over the past six months on the product to which I am making reference. The material that we have processed is not a matter of five coils or ten coils or anything of that nature. The volume of material that has been processed in this manner is considerable. Many tons have been processed this way.

Mr. Smigel made reference to success on low carbon wire. Now, I take that to mean that he encountered his difficulty on high carbon wire. For the benefit of you who are not familiar with this particular product, all the work that we have done to date has been on high carbon wire and rod. A typical reduction for 1060 steel, would be a rod size of 0.106, finish size 0.040, a speed of 1,200 fpm in six draws. One reassuring feature of the lubrication job being done is that there is an accumulation of lubricant in the mouth of each die providing lubricant for each reduction.

Continuing further on Mr. Smigel's comments regarding increased tank requirements for the use of this

particular operation, the use of this particular product entails the use of absolutely no additional equipment. Practically all wire mills have a borax tank. This particular product is used in conjunction with the borax tank.

Walter A. Smigel: I was wondering if with this particular lubricant you could, for instance, produce welding wire? Can you produce extra-clean, extra-bright wire?

Allen A. Brown: The wire is no brighter than wire normally drawn through soap powder.

Walter A. Smigel: Can you produce nail wire, cold-heading wire? My reason for asking is to point out that some types of wire such as rope wire can be made with one tank, but many different compositions and many tanks would be needed to produce the various types of finishes for wire.

Allen A. Brown: People who have tried this material feel the finish is comparable to the finish they are getting from borax coated wire. In many operations people are resorting to a borax dip. They are getting away from the lime as much as possible except in operations where the customer insists on a lime coated wire, but in applications where borax was previously used, this particular product has replaced it and has also replaced the use of lime on that particular coated wire.

Walter A. Smigel: Wire produced with a borax finish has some limitations, for instance, its use is questionable on some grades of spring wire. I did not want to give the impression from my previous comments that this particular process does not work; either high or low carbon wire being easier to draw down with lubricant coatings than rod. However, wire mills have many variables and at times have their ups and downs. Therefore, we do not believe lubricant-coatings will become the universal method for drawing rod and wire.

D. E. Whitehead: The reactive type of lubricant is particularly interesting to many of us engaged in reducing and drawing alloy steel products since optimum performance is adamant. Looking toward our texts on modern gear lubrication, we find a wide variety of certain re-active type lubricants applicable to metal drawing operations, and the full text has certainly not been explored at this time.

We find with interest that certain types of reactive lubricants that have been indicated for successful high load gear lubrication show value as metal drawing lubricants, yet these same species would be frowned upon as definitely non-applicable for the reduction of strip or sheet alloy rolling.

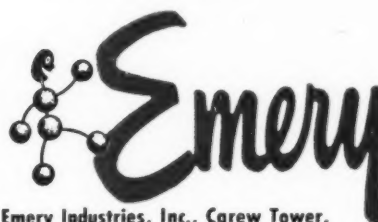
There are also those reactive types of lubricants that we find applicable to sheet and strip alloy reduction and to metal drawing operations which would be regarded outside of any consideration as gear lubricants, yet these lubricants are all typed within the scope category of reactive type lubricants. These facts or contradictions all lend fascination to any exploration of the



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known field of reactive lubricants for possible new application of existing lubricants or the development of new lubricants for alloy wire drawing.

The increasing use of diamond dies for alloy steel wire drawing brings to our attention new requirements in lubricants for the successful drawing of alloys also to effect reasonable economies in diamond die life. It appears that the reactive type lubricant is definitely indicated for this work, but leaves us concerned about the theoretical logic from the standpoint of a fitting selection of a reactive lubricant when applied to prevent welding between an alloy steel wire and a diamond die.

Certainly the field of application of the reactive type lubricants to alloy steel reduction by rolling and drawing is in its infancy and like most infants is attracting attention and developing demands.

I recently received a communication from one of our new wire mills reporting on the reactive type lubricants suggested for test. Very fine reductions were reported, but we were also asked if we had a customer that might require a couple of coils of alloy wire having a brilliant olive green cast.

H. E. Martin and James McElgin: In a general discussion of this nature, it is not always possible to cover the detailed characteristics of the many boundary lubricants. Mr. Brown has covered, in terms of coefficients of friction, the differences between simple lubrication as supplied by continuous oil films and the boundary lubrication which applies in the working of metals.

Liquid lubrication can exist up to a pressure of about 4,500 psi between adjacent metal surfaces. Boundary lubrication occurs between unit pressures of 4,500 and 450,000 psi. The average deep drawing operation involves pressures up to 10,000 psi. If there is any appreciable ironing of the metal, the pressures may be as high as 100,000 psi. Wire drawing, tube reducing, and cold extrusion of steel produce pressures in the range of 150,000 and 450,000 psi.

The various factors involved in a drawing operation are so complex that it is often impractical to select a drawing lubricant without an on-the-job analysis of the particular requirements by personnel with an expert knowledge of metal shaping operations and the formulation of lubricants applied to drawing practices.

Mr. Brown has discussed the development of a synthetic substitute for palm oil in cold reduction mills. There are many other new concepts in the lubricants used in the boundary lubrication involved in the cold forming and shaping of metals.

Among the new developments is the use of new extreme pressure agents and combinations. These have permitted in many operations the use of light-bodied oils or emulsions in place of the heavily pigmented products previously employed. Where a pigmented material is required, new colloidal pigments are being utilized. These pigments are about 5 microns in particle size in comparison to a size of 200 microns in the finest grade of whiting. These finer pigments cause less die wear. They produce better finishes with less possibility of scratching. They remain suspended indefinitely in water mixtures and can be cleaned from the work as readily as a soluble oil.

On extremely heavy drawing operations where pigmented compounds or surface reactive extreme pressure agents cannot be used, such as on work which is to be vitreous enameled, polar type lubricants are being employed.

Lubricants having polar activity have made possible extremely heavy operations such as the drawing of one-piece steel bathtubs and sinks without intermediate anneals or the use of pigments or extreme pressure agents. Polar lubricants consist of molecules having two parts, one charged negatively at the end of a long chain and the other end with a positive charge similar to the positive and negative ends of a small magnet. These lubricants are effective because these molecules are attracted and held in position on the metal surface by their electrical charges. The initial layer of molecules is attached so strongly to the metal surface that high shearing stresses are required to displace it. Other layers of molecules are built up by electrical attractions on the surface of the first layer. Under the most severe drawing conditions, all but the initial layer is likely to be displaced. However, in most cases the initial layer of molecules is sufficient to provide adequate lubrication and to prevent welding.

The trend in many high production drawing operations is to the so-called "dry film" lubricants. In this practice, the blanks or sheet stock are immersed for a short period in a heated dilute water solution of the drawing compound. They are then withdrawn and allowed to dry by means of the residual heat remaining in the metal. In some cases a short baking cycle is used to evaporate the moisture remaining on the surface. After the evaporation of the moisture, a dry film of the lubricant, about 0.001 inch in thickness, is left on the metal surface. In some cases the film is composed of a mixture of crystalline alkalies such as borax and trisodium phosphate.

With another type of compound, the residual film is composed of an alkali mixture bound to the metal surface in a matrix of regenerated cellulose. The complex mixture of alkalies used produces a deposition of crystalline particles of a controlled size and increased adhesion to the metal surface. Mixtures of alkalies and high titre soaps employed in wire drawing practice are also being used in dry film drawing lubricants.

Another new type of dry film lubricant is composed of a mixture of regenerated cellulose and high melting point waxes possessing exceptional lubricating properties. The dry film which is produced on the work is very tough and adherent. Parts can be stored for indefinite periods before and after drawing without any danger of rusting or deterioration of the drawing qualities of the coating. This film consists of a matrix or sponge of regenerated cellulose tightly bound to the metal surface. This cellulose acts as a solid lubricant which will withstand the high pressure produced by successive reductions. This sponge or matrix is filled with high melting point waxes which are forced to the surface by the die pressure. This supplies any required additional lubrication.

The matrix of cellulose prevents the lubricating wax

from being stripped away by the die pressure. A modification of this particular type of dry film drawing lubricant contains a percentage of colloidal pigment. This combination is highly efficient on applications where the ironing action is severe as in the cold drawing of bar stock.

Mr. Brown has discussed the importance of the easy cleanability of the drawing lubricant from the work. In the field of palm oil substitutes in the cold reduction of steel sheet, coordinated research recently completed

indicates the possibility of a satisfactory cold rolling lubricant or palm oil substitute which can be cleaned from the sheet stock by cold cleaning practices. This cold cleaning practice, to be used in the present continuous cleaning lines, does not involve the use of solvents.

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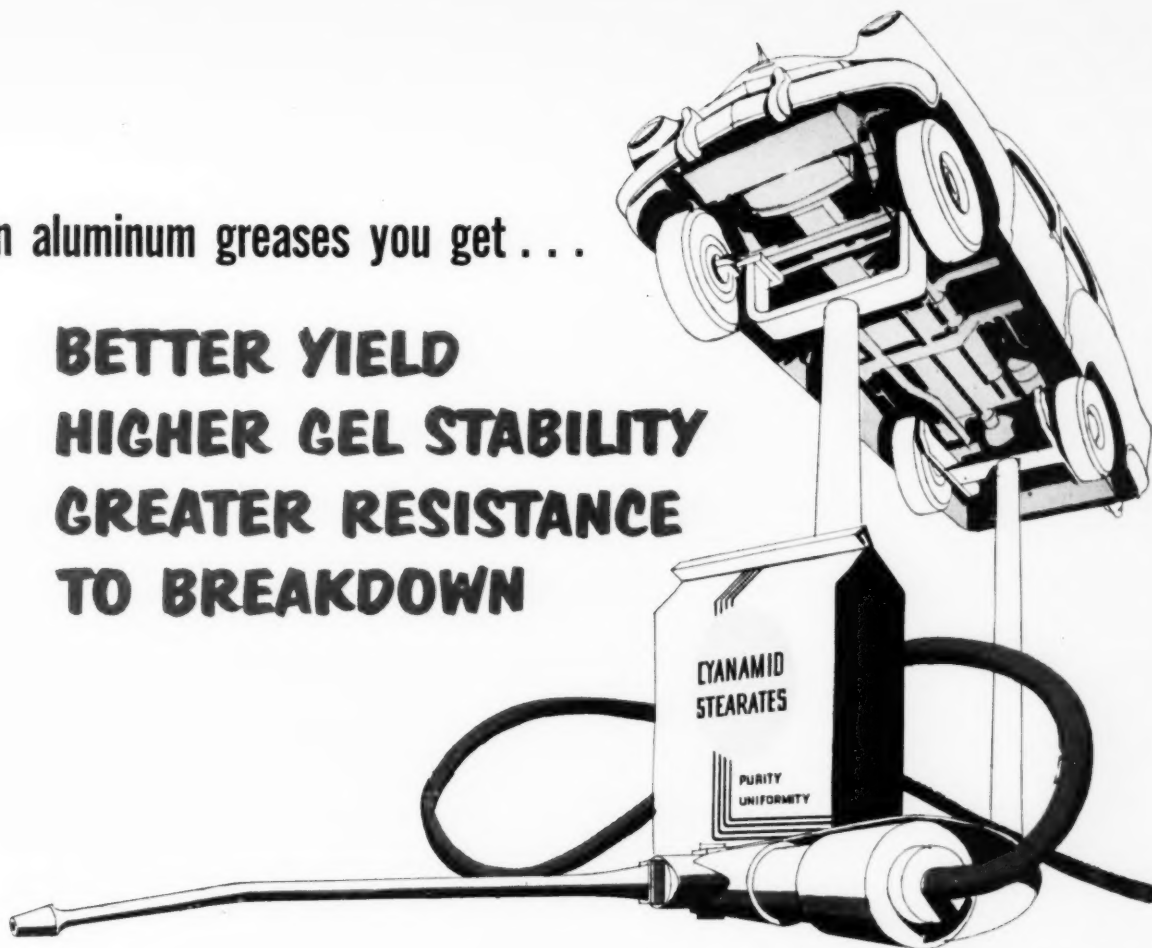
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Patents and Developments

Fibrous Lubricating Grease

The preparation of fibrous calcium and/or lithium soap base greases by use of non-conjugated unsaturated acids and a special processing technique, is described in U. S. patent 2,646,401 issued to Standard Oil Development Company. The greases are made in the conventional manner and then cooled with constant agitation from their melting point to their transition temperatures. After the latter has been reached, the greases are further cooled by either panning or continuous grease cooling methods.

These greases are prepared by incorporating 5-50% of the metal soap of unsaturated acids in lubricating oil. The fatty acids preferably of 75 iodine value or above and a quarter of the mineral oil are heated to about 150°F. The metal hydroxide is added and the temperature of the resulting mixture is raised to 220°F., at which point another quarter of oil charge is added to allow the soap concentrate to be stirred more easily, and the batch is held at 220°-240° F. until dehydration is completed. Thereafter the remainder of the oil is added at 300°F. and the temperature is raised slightly above the melting point of the soap until the batch is a homogeneous fluid with no curds showing.

If the lithium or lithium-calcium, or lithium-strontium soap greases are cooled from their melting points (usually 380°-400°F. for Li grease, or 320°-330°F. for Li-Ca grease) to their transition temperatures (about 340°F. for Li and about 280°-300° for Li-Ca) with constant agitation, preferably a severe milling action, and then cooled to handling temperatures in a normal manner without agitation, there results a considerable increase in fibrous structure.

Cottonseed fatty acid soaps are specified in the examples given.

Greases Gelled with Inorganic Agents

Improving water resistance of greases gelled with silica and similar materials has been the subject of a number of patents discussed previously in this column. A recent patent (2,647,872) issued to Shell Development Company, proposes the use of certain hydrophobic surface active hydroxyl-containing organic compounds together with certain succinic or succinamic acids, anhydrides, esters or amides for such purpose.

The succinic or succinamic acids useful in the present compositions are those bearing alkyl and alkenyl substituents, preferably having 10-24 carbon atoms. They can be prepared according to the process set forth in the Eichwald patent 2,055,456.

The alkyl or alkenyl dicarboxylic acid or anhydride can be reacted with an amine to obtain a condensation product suitable as an additive for the greases. Examples of such amines include ethylene diamine, diamino octane, phenylene diamine, etc.

The aliphatic hydroxy compound to be used includes hydroxy fatty acids, polyhydric alcohols, esters of glycols or glycerols, etc., such as 12-hydroxy stearic acid, octane diol, 1,10 decane diol, monobutyl ether of tetraethylene

glycol, dodecyl mercaptan (which can be substituted for hydroxy compounds), and the like. The amount of hydroxy compound varies within about 20-50% of the weight of the gel, or about 1-5% on the weight of the grease. The amount of the condensation product used is about the same.

One example specifies a mineral lubricating oil milled with 5% by weight of a silica alcogel. During the milling, 2.4% of the triglyceride of 12-hydroxystearic acid and the same amount of octadecenyl succinic acid are added. A grease stable to boiling water is obtained which lasted 52 hours in the Shell Roll Tester before failure.

Consistency-Maintaining Greases

A method claimed to produce improved greases capable of maintaining their consistency under variable conditions, resist bleeding, and possess good mechanical and dimensional stability is described in U. S. Patent 2,648,634 issued to Shell Development Company.

Broadly, the process resides in forming a solution of a gelling agent in a lubricant liquid, rapidly cooling the solution, reheating the resulting mixture to about the solution temperature, and then cooling the mixture while subjecting it to shearing action.

Specifically, it involves saponifying a fatty acid glyceride or a fatty acid in admixture with a suitable liquid lubricant, with an alkaline-acting saponifying agent, such as lithium hydroxide, to form a soap concentrate, such as one containing about 30% by weight of soap, heating the resulting admixture to or slightly above solution temperature of the soap in the lubricant, rapidly quenching the resulting solution with additional liquid lubricant, as required to produce a grease structure, reheating the quenched material to slightly below solution temperature, and thereafter cooling the reheated material, while subjecting it to shearing, to about 30°C. below the solution temperature.

To provide a better understanding of the principles underlying the requirement for specific processing temperatures, such as the solution temperature, it is advantageous to compare these temperatures with changes in the gelling agent-liquid lubricant system indicated by differential thermal analysis. The changes which take place in going from a solid-liquid mixture (gel) at room temperature to a homogeneous substantially complete solution at solution temperature are much more complex than the familiar solvent-solute systems. Several changes at different temperatures are involved and processing techniques must be coordinated with them.

A differential thermal analysis of a lithium 12-hydroxystearate-mineral oil system is shown in Figure II which depicts the occurrence of phase changes (manifested by changes in temperature-time relationships of the sample) at temperatures which correlate well with the mechanical behavior of the grease when heat is added, or improved. Significant temperatures are found at about 196°C. and about 165°C. An examination of the phenomenon of "solution" of lithium 12-hydroxystearate

soap in a mineral lubricating oil shows that the action is more complex than merely increasing solubility with increasing temperature. For example, even at 0.1% by weight soap concentration the solution temperature is still about 196°C. A suitable and likely explanation of the broad transition temperature range (165° to 196°C.) is that the transition temperature range can be likened to a type of depolymerization where the polymer exists by virtue of hydrogen bonds. These normally do not have the sharp transitions found with well-defined crystalline materials. Thus a considerable portion of the heat input between 165°C. and 196°C. is absorbed in "loosening" the structure of the solid soap particles and at higher temperatures a true solution is formed. Using this interpretation as a working model a fairly adequate explanation of the processing requirements and subsequent mechanical properties of the grease can be presented. Figure I gives a temperature profile of the grease-making process covered by the patent.

It has been found that the solution temperature of a gelling agent in a liquid lubricant carrier is influenced by the viscosity and/or the molecular weight of the carrier used. Accordingly, if lighter or heavier molecular weight carriers, such as mineral oils, are used, processing temperatures should be adjusted accordingly. For example, it has been found that the solution temperature of lithium 12-hydroxystearate in mineral oils of varying viscosity increases with increasing viscosity, although no differences were observed when oils of varying degrees of refinement were used. The data in Table I show the change in solution temperature of lithium 12-hydroxystearate with change in viscosity of a mineral lubricating oil. The mineral oils used were solvent extracted, acid treated, mineral oil distillates, although a similar situation holds when unextracted raw lube distillates are used.

TABLE I

Viscosity in Centistokes at 100°F.	Solution Temp., °C.
20	191
32	194
100	196
325	199

As indicated hereinbefore, of the various processing factors in the formation of a superior grease, the initial formation of the gelling agent fibers is probably the most important. The degree of supersaturation and the number of crystal nuclei present in a solution are controlling factors on the size distribution of the solute particles (gelling agent) which are precipitated. Sudden lowering of the solution to create a high degree of supersaturation and assuring ample crystallization sites (crystal nuclei) so that the solid phase can precipitate at many points, enhances the production of many small crystals or fibers. The effect of this size distribution and its relationship to specific conditions under which it is achieved on several grease properties is set forth hereinafter.

The specific crystallization conditions used to effect precipitation of the gelling agent from its solution in the liquid lubricant carrier can be related to the resulting consistency or penetration by an expression involving (1) the temperature to which the gelling agent solution was heated, which temperature controls the number of

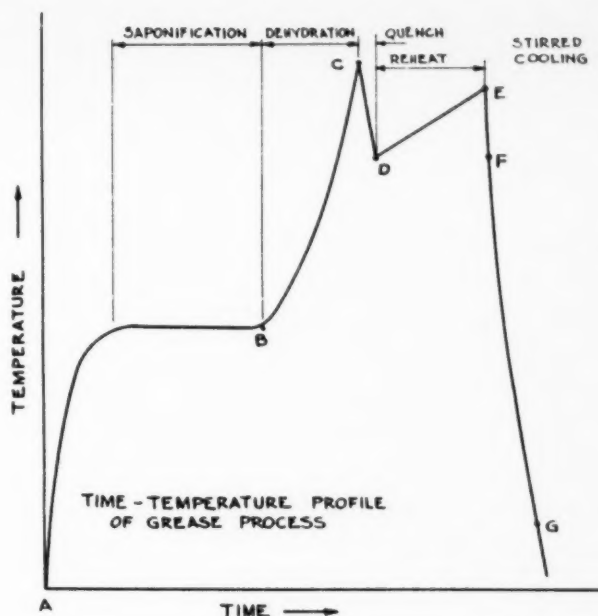
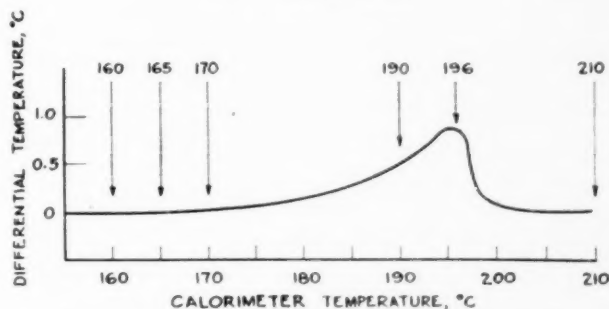


FIG I

available crystal nuclei remaining in the solution and (2) the temperature to which the solution was quenched as by rapid cooling or by quenching with additional lubricant carrier, which temperature determines the amount of supersaturation existing at the moment of crystallization. Thus, specifically, considering the temperature limits of 196° and 165°C. (as determined by thermal analysis) which represent the solution temperature and the temperature at which a lithium 12-hydroxystearate soap-mineral oil system is "frozen," respectively, the excess of the sum of the temperatures to which the mixture is heated for solution and then quenched over the sum of the temperatures represented by 196° and 165°C., is termed the amount of "superheating" and has been correlated with initial consistency (after 300 strokes ASTM) in Figure III, for various lithium 12-hydroxystearate-mineral oil greases. As shown by Figure III, those samples of a lithium 12-hydroxystearate grease which were heated to a temperature (solution temperature) just sufficient to dissolve all of the lithium soap but not to destroy the crystal nuclei therein (which latter would happen if the solution temperature was substan-

(Continued on page 29)



THERMAL ANALYSIS OF A LITHIUM 12-HYDROXYSTEARATE GREASE. 6% SOAP IN MINERAL OIL

FIG. II

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Although the temperature at which Bentone greases will ignite is set by the fire point of the oil (as in the case of conventional greases), Bentone 34 greases, when properly compounded *will not melt*, even while burning.

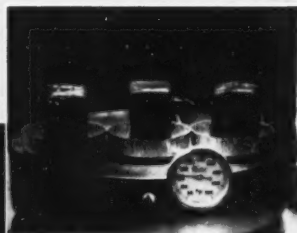


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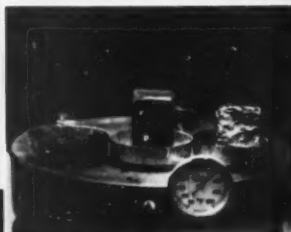


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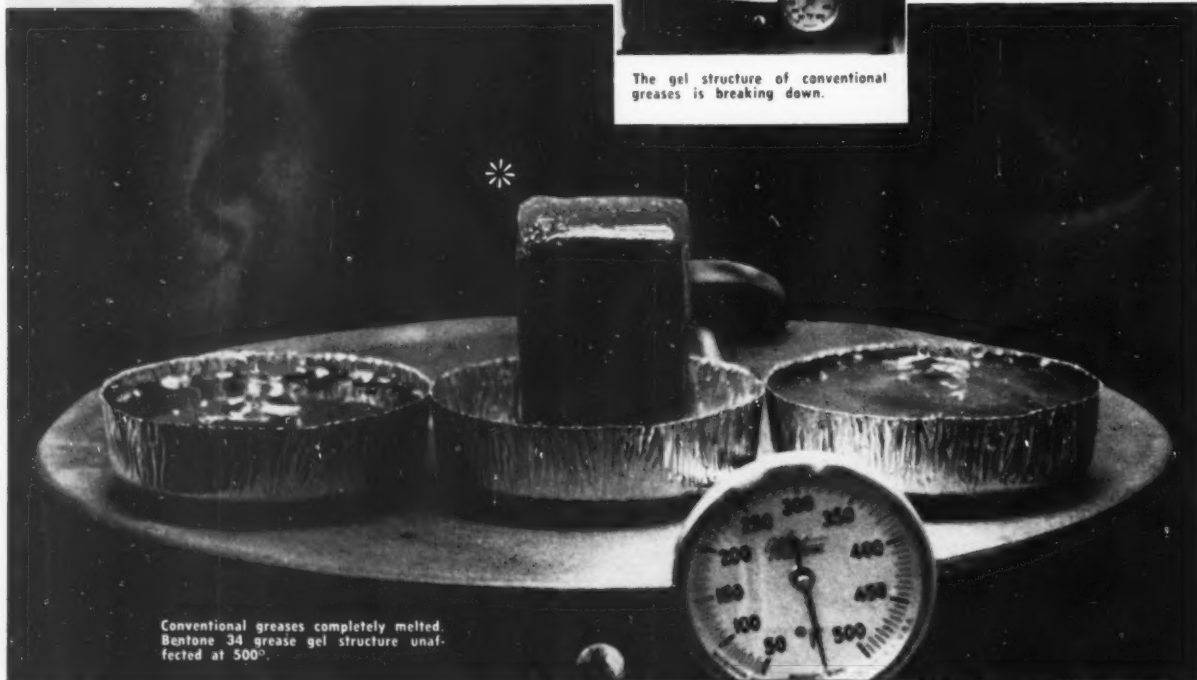
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Bentone 34 grease, center, between two conventional soap base greases.



The gel structure of conventional greases is breaking down.



Conventional greases completely melted. Bentone 34 grease gel structure unaffected at 500°.

tially exceeded), and thereupon quenched (as by rapid cooling or the addition of coil oil), had appreciably lower penetration values, as measured by ASTM Test Procedure D217-48 titled "Cone Penetration of Grease." In general, it has been found that those greases manufactured according to the invention with only a minor amount of superheat, preferably not over 10°C., have very satisfactory penetration values.

To demonstrate this effect further, a lithium-12-hydroxystearate grease sample was heated to well above solution temperature (204°C. for about 10 minutes) to destroy the crystal nuclei, the grease was then seeded with about 0.035% of its weight of a preformed grease of suitably sized fibers to provide new crystallization sites and rapidly cooled to about 175°C. The resulting grease had a penetration value of 288 instead of an expected 310 or greater.

It has also been observed that after precipitation of the gelling agent by quenching a solution of the gelling agent in a liquid lubricant carrier, extended heating for a period of about 1/2 to 1 hour at temperatures somewhat below the solution temperature, such as about 5° to 20°C. below said solution temperature, for example at a temperature of from about 180° to about 190°C. for a lithium 12-hydroxystearate mineral oil grease, leads to progressive softening of the finished grease. It is considered that during this heating period chance cross links in the gelling agent's "fiber bundles" become consolidated so that in the subsequent stirring operation there is more breakage of the preferred long fibers.

The control of bleeding grease by regulation of the gelling agent fiber size therein is considered in this invention to be a problem involving filtration of the liquid lubricant carrier therein from the mass of gelling agent fibers. Formerly, it was considered that bleeding was the result of syneresis or the resultant "forcing out" of the lubricant-carrier liquid phase (e.g., mineral lubricating oil) due to the shrinkage of the gelling agent solid phase. Accordingly, in the present view the entangled gelling agent fibers (e.g., soap) act like a filter mat from which oil separates under the influence of gravity so that where a liquid "head" of carrier exists there is a tendency for the liquid carrier to collect at the low point. This separation (flow) is resisted by (1) the capillary attraction of the gelling agent fibers for the liquid carrier and (2) by the rigidity or gel strength of the grease mass supporting the static "head" of liquid carrier.

Accordingly, in view of the above hypotheses, bleeding should be less for a system comprising the liquid lubricant carrier held by relatively fine fibers. Since it is possible to prepare a grease under conditions, according to the invention, conducive to the formation of finer fibers, it is, therefore, possible to thereby directly control bleeding.

A series of experiments were performed wherein samples of 6% by weight lithium 12-hydroxystearate grease in mineral oil were produced under varying conditions and the bleeding propensities of these samples were determined.

The bleeding test found most satisfactory is one based on static bleeding in a half-pound tin of grease and per-

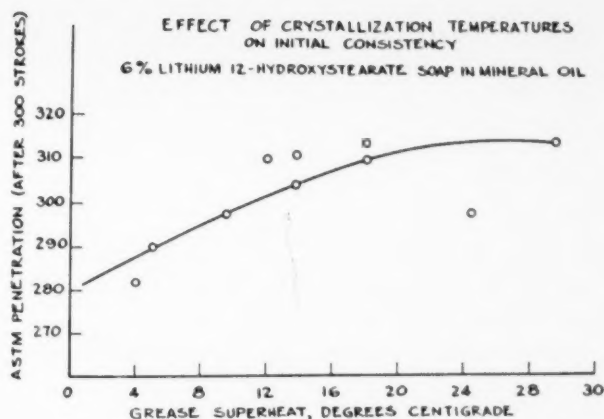


FIG. III

formed in the following manner. A vertical groove was cut to the bottom of the grease sample with a spatula (1/8 in. wide) and the sample stored at room temperature. After two weeks and again after six weeks, the free oil was decanted and measured, allowing a one-hour drain period. The groove was used primarily to decrease the testing time. The data obtained are graphically illustrated in Figure IV and they reveal that when crystallization temperatures, as indicated by a greater amount of "superheat," are such that as a result relatively coarse soap fibers are formed there is an increased tendency towards bleeding. In general, the maximum temperature of the gelling agent solution should be limited to a few degrees, preferably not over 5°C., above the solution temperature in order to obtain greases having low bleeding losses. Also the temperature of the gelling agent solution should be lowered (quenched) sufficiently and quickly to provide a high degree of supersaturation and thereby assure the growth of only small crystals. It is preferred that the temperature after quenching should be between about 15°C. to about 50°C., preferably about 30°C., below the solution temperature but may be greater or lesser according to the materials used and results desired.

It is pointed out that a high temperature, i.e., a temperature appreciably greater than the solution temperature, is to be avoided because of the resulting destruction of crystal sites (crystal nuclei) thereby. Furthermore,

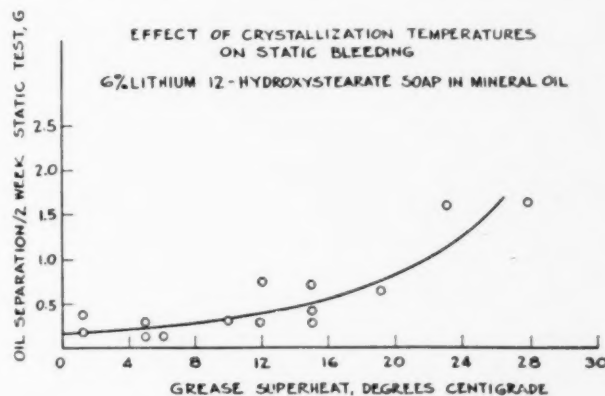


FIG. IV

heating for an extended period of time at a temperature only slightly (2-10°C.) above solution temperature is to be avoided because crystal nuclei (molecular aggregates) are destroyed thereby. Thus a lithium soap grease prepared by holding a concentrate thereof in mineral oil at a temperature above solution temperature, for example, 10 minutes at 200°C. (solution temperature 196°C.) before quenching by adding thereto additional mineral oil, gave a considerably higher rate of bleeding than did a similar sample which was quenched immediately after reaching 200°C., although the degree of "superheating" was the same for both samples.

The critical relationship between crystallization temperature and crystal size of the gelling agent can be minimized by quenching a more dilute solution of the gelling agent. Accordingly, instead of quenching a 30% by weight concentrate of gelling agent with the remainder of the liquid carrier to produce a 6% grease, a suitable alternative procedure would be to quench a relatively low "concentrate," say about 7% by weight gelling agent (which would contain about 84% of the total liquid lubricant carrier in the finished grease) with the additional liquid lubricant carrier required to give a 6% grease. The additional liquid carrier should be at an appropriately relatively lower temperature, about -10°C., in order to obtain rapid quenching and the proper quench temperature. Thus 6% by weight lithium 12-hydroxystearate mineral oil grease made in the above manner to give a temperature after quenching of 179°C. from a solution at a temperature of 200°C. (i.e., 18°C. superheat) would be expected, according to Figure IV, to have a bleeding value of at least 0.5 gm. Actually a bleeding value of only 0.05 gm. was obtained. In addition, it is pointed out that a grease produced by quenching a dilute solution requires less vigorous stirring to form a smooth grease because aggregation of the precipitated crystal fibers is inhibited. It is, of course, realized that instead of preparing a soap concentrate, it is possible to prepare a grease containing all the components thereof in the desired proportions, thereby eliminating the necessity of adding additional carrier. The heated grease may then be quenched as by rapid cooling in a heat exchanger and further treated in accordance with the invention.

In summary, to produce a superior substantially non-bleeding grease, excellent results are obtained when a gelling agent (soap) and liquid carrier (mineral oil) are heated to, or slightly, about 1° to 5°C., preferably about 1° to 2°C., above solution temperature, maintained at that temperature for only a relatively short time (1-10 minutes), so that although the melt appears to be substantially uniform and homogeneous there remain therein molecular aggregates or crystal nuclei; quenched from a fairly dilute melt with additional liquid carrier to a temperature substantially below the solution temperature, about 30°C. below; reheated to a temperature slightly, from about 2° to about 5°C., preferably about 2°C., below solution temperature and then vigorously agitated while being cooled to a temperature substantially below (about 30°C.) the solution temperature.

Dimensional stability or the resistance to slumping, particularly at elevated temperatures, is an important

property of a grease relating to the ability of the grease to stay in place during use. Slumping takes place under gravity when the mass of the grease exceeds the ability of the fiber cross links of the gelling agent therein to support the structure. As the temperature increases the individual points of contact supporting the mass become weaker, leading to eventual collapse of the "scaffolding" supporting the grease and holding the oil therein.

Not only is the crystallization (precipitation) step important in determining the distribution of the gelling agent (soap) fibers but also other steps of the process involving aggregation of the fibers have considerable effect upon dimensional stability. Obviously, if the fiber bundles formed by aggregation are not completely dispersed by the shearing action during cooling or if only a relatively few large fibers have been formed in the crystallization step, there will be few contact points holding the entire grease mass together and greases of this type will slump very easily. Dimensional stability (slumping tendency) can be fairly well correlated with processing conditions and temperature (i.e., solution and quench temperature, expressed as "superheat"). Slumping data for a range of "superheat" temperatures are set forth in Table II below. The data show that only those samples prepared at the lower temperatures (small amount of superheat), according to the teaching of the invention, resisted slumping at 110°C.

The test used to evaluate slumping tendency is a simple modification of the well-known wheelbearing test. 100 grams of grease is spread uniformly on the inside of a 600 cc. beaker to give a cylinder of grease approximately 1/4" thick and 3" high and placed about 1/4" above the bottom of the beaker. The beaker containing the sample is placed in an oven at 110°C. for one hour and the extent of slumping estimated from the proportion (percentage) of the bottom of the beaker covered by the grease. Bleeding can also be estimated in this test.

TABLE II
Effect of Crystallization Temperatures on Static Bleeding and Dimensional Stability

(6% lithium 12-hydroxystearate in mineral oil stirred from 190°C. to 165°C.)

Bleeding, gms./2 weeks	Slump Test, 110°C.	Super- heat,* °C.	Max. Melt Temp., °C.	Quench Temp., °C.	ASTM Penetra- tion, 300 Strokes
0.1	pass	5	196	170	287
0.1	do	6	199	168	300
0.2	do	0	197	164	290
0.2	do	5	196	170	299
0.3	do	1	197	163	307
0.3	do	8	197	172	296
0.3	25°	10	200	171	299
0.3	25°	12	200	173	289
0.3	75°	15	205	171	284
0.4	50°	15	205	171	312
0.7	100°	12	202	171	310
0.7	100°	19	207	173	317
1.7	100°	23	200	184	301
1.7	100°	28	211	188	320

*Superheat: The sum of the temperatures in degrees centigrade above 165°C. for the quench temperature and above 196°C. for the melt temperature.

When a gelling agent (e.g., lithium 12-hydroxystearate) is precipitated from its hot liquid carrier (e.g., mineral oil) solution, the resulting crystals usually have a tendency to aggregate into fairly large masses or clumps. This results in a "grainy" grease or gelling agent (soap)-liquid carrier (oil) slurry having none of the properties of a grease. As pointed out hereinbefore, this tendency to form "clumps" can be lessened by crystallizing the gelling agent from a dilute solution. In general, however, it is necessary to subject the grease mixture to a shearing action in order to disperse and break up these crystal aggregates. The shearing can be carried out at room temperature but the energy required would be excessive. However, at a temperature somewhat below the solution temperature (e.g., for a lithium 12-hydroxystearate-mineral oil grease a temperature of between about 165° and 195°C.) the crystal bonds are much weaker and a smooth grease can easily be prepared by stirring the hot slurry. The effect of maximum stirring temperature upon grease consistency is shown by Figure V, wherein a lithium 12-hydroxystearate grease concentrate was heated to about 200°C. and then portions were quenched with additional mineral oil to give greases containing 6% and 7% by weight soap. Thereafter portions of these greases were reheated to certain selected temperatures and then stirred at 750 R.P.M. in a closed kettle while cooling to about 165°C. The various greases were then tested as to their consistency (ASTM penetration test—300 strokes) and the values noted were plotted against maximum stirring temperature, as illustrated by Figure V. The increased effectiveness of stirring at higher temperature up to solution temperature, is strikingly evident therefrom. However, when the greases are reheated above the solution temperature, all the fibers (crystals) previously formed by quenching disappear and the subsequent recrystallization which takes place during the relatively slow cooling and stirring period leads to the formation of a rather coarse, grainy grease since a slow rate of cooling is conducive to the formation of very large fibers (crystals).

It is pointed out that if stirring after reheating is stopped before the grease has cooled substantially below the solution temperature, i.e., at least 15°C. below solution temperature, fiber reaggregation takes place so that high penetration values are obtained. Furthermore, if stirring of the grease is continued to room or packaging temperature, that is, to a temperature at least about 100°C. below solution temperature, a small amount of softening of the grease occurs due to the mechanical breakdown of the fiber structure of the grease.

Bleeding resistance and dimensional stability are affected by maximum stirring temperatures to the extent that dispersion of the fibers is promoted by higher temperatures. For example, for a 6% lithium 12-hydroxystearate-mineral oil grease, bleeding resistance improved when the maximum stirring temperature was increased to 194°C. instead of 190°C. In general, the maximum stirring temperature should be slightly below between about 1° to 5°C., preferably about 2°C. below the solution temperature.

Although the practice of the invention and discussion of the various operational factors involved have been

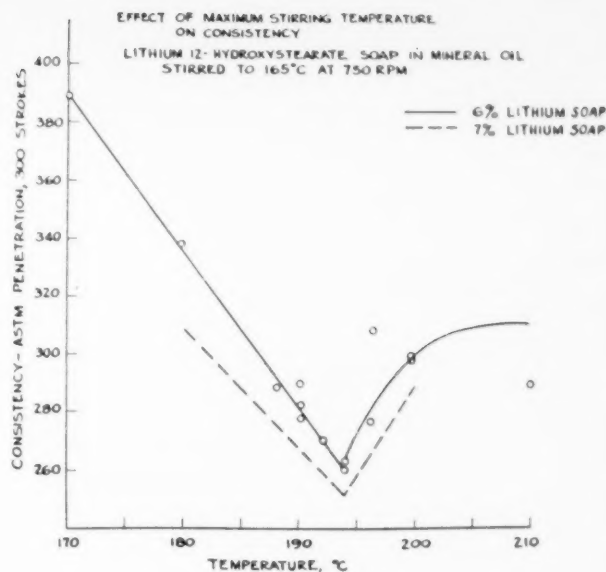


FIG. V

illustrated with mineral oil base greases containing lithium 12-hydroxystearate as gelling agent (soap), the invention is applicable to other combinations of soaps and oils. The gelling agents used to form the grease may be soap of fatty acids and/or their glycerides. The saponifiable material may be higher fatty acids or mixtures of the same having from 10 to 32 carbon atoms and they may be saturated, unsaturated or polar-substituted fatty acids, such as capric, lauric, myristic, palmitic, stearic, arachidic, behenic, lignoceric, myristoleic, palmitoleic, oleic, linoleic, ricinoleic, erucic acids, cottonseed oil fatty acids, palm oil fatty acids, hydrogenated fish oil fatty acids, and their mixtures and/or their glycerides, such as lard, beef, rapeseed, palm, menhaden, herring oils, etc. Other acids may be included, among which are: acid produced by oxidation of petroleum oil and waxes, rosin acids, tall oil acids, abietic acids, including dehydroabietic acid and dihydroabietic acid; naphthenic acids, petroleum sulfonic acids and the like.

A particularly preferred class of saponifiable materials is the class of hydroxy fatty acids and their glycerides, such as dimethyl hydroxy caprylic acids, dimethyl hydroxy capric acids, hydroxy phytostoleic acid, ricinoleic acid, ricinelaidic acid, 12-hydroxystearic acid, 9, 10-dihydroxystearic acid, 4-hydroxypalmitic acid, linolic acid, sativic acid, lanoceric acid, dihydroxygadoleic, dihydroxybehenic acid, quince-oil acid and the like. The preferred hydroxy fatty acids are those in which the hydroxy group is at least 12 carbon atoms removed from the carboxyl group. Also, it is preferable to use hydroxy fatty acids having at least 10 carbon atoms and up to about 32 carbon atoms and preferably those having between 14 and 32 carbon atoms in the molecule. Instead of using the free fatty acids containing a hydroxy radical their glycerides can be used, such as castor oil or hydrogenated castor oil or mixtures of free hydroxy fatty acids and their glycerides can be used. Mixtures of

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hydroxy and non-hydroxy fatty acids can be used to form soaps for use in the invention.

The saponifying agent used to make the soap may be alkaline acting metal compounds of Li, Na, K, Cs, Ca, Sr, Ba, Cd, Zn, Pb and Co, and preferably the oxides, hydroxides and carbonates of the alkaline metals of valences from 1 to 3. Mixtures of soaps can be used and the soaps can be made in situ or pre-made soaps can be used to form the grease. Specific examples of preferred soaps and mixtures thereof are the alkali metal fatty acid soaps, such as lithium stearate, lithium hydroxystearate, lithium ricinoleate, lithium soap of hydrogenated fishoil fatty acids, lithium soap of mixed stearic and hydroxystearic acids, sodium stearate, sodium hydroxystearate, sodium oleate, potassium oleate, potassium rosinate, calcium stearate, calcium hydroxystearate, barium hydroxystearate, barium stearate, barium soap of mixed stearic and hydroxystearic acids, lithium soap of mixed oleic and hydroxystearic acids; sodium soap of mixed stearic and hydroxystearic acids; barium soap of mixed stearic and oleic acids; lead ricinoleate; mixed soaps of lithium stearate and sodium stearate, mixed soaps of lithium hydroxystearate and sodium stearate; mixed soaps of lithium hydroxystearate and calcium stearate, etc. Amine soaps, such as triethanolamine oleate can be used in combination with metal soaps or as the only gelling agent.

Instead of using only soaps as the gelling agent, mixtures of soaps and other gelling agents, such as organic or inorganic aerogels, silica aerogels, alumina aerogels,

nylon or cellulose fibers can be used in addition to the soap as the gelling agent.

The soap content of grease compositions of this invention may vary over wide limits between about 3 to 20% and may be as high as 50% by weight. In practice, it is possible by choice of suitable grease-forming lubricant bases to manufacture satisfactory lubricating greases containing only about 10% or less by weight of the soap mixtures. Very satisfactory products are obtained with a total soap content of about 6% to 8% by weight of the finished grease.

The grease-forming lubricant bases used in preparing the greases of the present invention may vary widely in character and include mineral oil of wide viscosity range, the range varying from about 100 SSU at 100° F. to about 2000 SSU at 100° F. The viscosity index of the oil can vary from below zero to about 90 or higher and can have an average molecular weight ranging from about 250 to about 900 or higher. It may be highly refined and solvent treated if desired by any known means. A preferred mineral oil is one which has a viscosity of 300 to 700 SSU at 100° F., a viscosity index of from 40 to 90, or even higher, and an average molecular weight of 350 to 750. Instead of using straight mineral oil as the base, synthetic oils and lubricants may be substituted in part or wholly for the mineral oil. Among the synthetic lubricants which can be used are: polymerized olefins; polyalkylene glycols and their partial or complete ethers and esters; organic esters, e.g., 2-ethyl-hexyl sebacate, dioctyl phthalate, tri(ethylhexyl) phosphate; polymeric tetrahydrofuran; polyalkyl silicone polymers, e.g., di-

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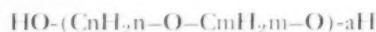
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methyl silicone polymer; alkylated aromatics, such as waxylated naphthalenes, etc. Under some conditions of lubrication minor amounts of a fixed oil such as castor oil, lard oil, etc., may be admixed with the hydrocarbon oil and or synthetic oil used in making grease compositions of this invention.

Particularly useful stabilizing agents for grease compositions of this invention are the alkylene glycol and/or alkylene thio glycol polymers, including their mixtures, as well as their monoester and/or ether derivatives. The alkylene glycol polymeric materials, also named polyoxyalkylene diols, can be represented by the following general structural formula:



wherein m and n are the same or different integers in a given molecule and a is an integer. Preferably the polymeric alkylene glycols as represented by the above general formula should be such that the product of the factor a and the number of carbon atoms within the brackets should be at least 6 and more.

The higher polyalkylene glycols having between 2 and 6 carbon atoms in the alkylene group are most effective as additives of this invention and those containing the ethylene and propylene groups are preferred. The average molecular weight of the polyalkylene glycols may be from about 200 to about 7,000 and the preferred molecular weight being from about 600 to 6,000, it being understood that such compositions are always mixtures

of various molecular species of different molecular weights.

To greases of this invention there may be added small amounts of other soaps or salts, generally in amounts of less than 2% for additional benefits. For example, there may be incorporated into sodium soap grease as described above a minor amount of aluminum soap or alkali and alkaline earth metal naphthenates, acetates, hydroxybenzoate, alpha-hydroxystearate, alpha-hydroxypropionate, beta-hydroxypropionate, gamma-hydroxyvalerate, Ca salt of alkylphenol-formaldehyde condensation product, Zn dibutyldithiocarbamate, etc.

Minor amounts of oxidation inhibitors can be added to grease compositions of this invention with benefit, such as N-butyl paraphenylene diamine. Also effective as oxidation inhibitors are alpha or beta naphthylamine, phenyl-alpha- or beta-naphthylamine, alpha-alpha or beta-beta dinaphthylamine, diphenylamine, tetramethyldiamino-diphenylmethane, petroleum alkyl phenols, and 2, 4-ditertiary-butyl-6-methyl phenol.

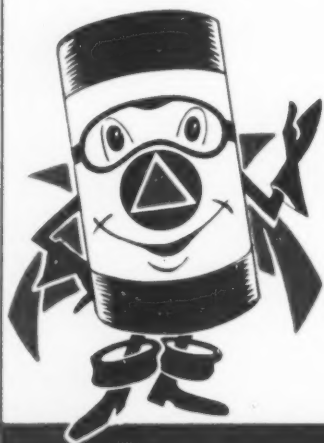
Corrosion inhibitors which are particularly applicable with compositions of this invention are N-primary amines containing at least 6 and more than 18 carbon atoms in the molecule such as hexylamine, octylamine, decylamine, dodecylamine, octadecylamine, heterocyclic nitrogen-containing organic compounds such as alkyl substituted oxazolines and oxazoline salts of fatty acids.

Extreme pressure agents can be added to such greases and the preferred agents comprise esters of phosphorus

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acids such as triaryl-alkylhydroxy-, alkyl-, aralkyl-phosphates, thiophosphates, or phosphites, etc., neutral aromatic sulfur compounds such as diaryl sulfides and polysulfides, e.g., diphenyl sulfide, dicresol sulfide, dibenzyl sulfide, methyl butyl diphenol sulfide, etc., diphenyl selenide and diselenide, dicresol selenide, and polysele-nide, etc., sulfurized fatty oils or esters of fatty acids and monohydric alcohols, e.g., sperm oil, jojoba oil, etc., in which the sulfur is tightly bound; sulfurized long-chain olefins obtained by dehydrogenation or cracking of wax; sulfurized phosphorized fatty oils, acids, esters, and ketones, phosphorus acid esters having sulfurized organic radicals, such as esters of phosphoric or phosphorus acids with hydroxy fatty acids, chlorinated hydrocarbons such as chlorinated paraffins aromatic hydrocarbons, terpenes, mineral lubricating oils, etc., or chlorinated esters of fatty acids containing the chlorine in positions other than the alpha position.

Additional ingredients which can be added are anti-wear agents such as oil-soluble urea or thiourea derivatives, e.g., urethanes, allophanates carbazides, carbazones, etc.; or rubber, polyisobutylene, polyvinyl esters, etc.; viscosity index (V.I.) improvers such as polyisobutylene having a molecular weight above about 800, volatilized paraffin wax, unsaturated polymerized esters of fatty acids and monohydric alcohols, etc.; oiliness agents such as stearic and oleic acids and pour point depressors such as chlorinated naphthalene to further lower the pour point of the lubricant base.

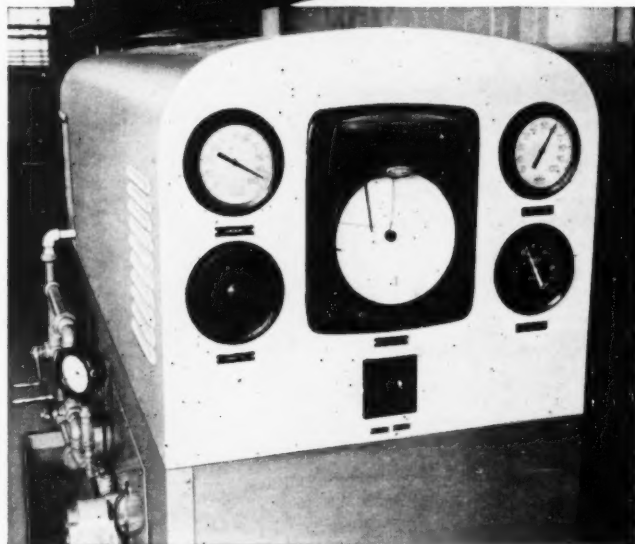
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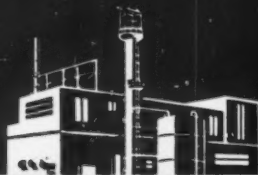
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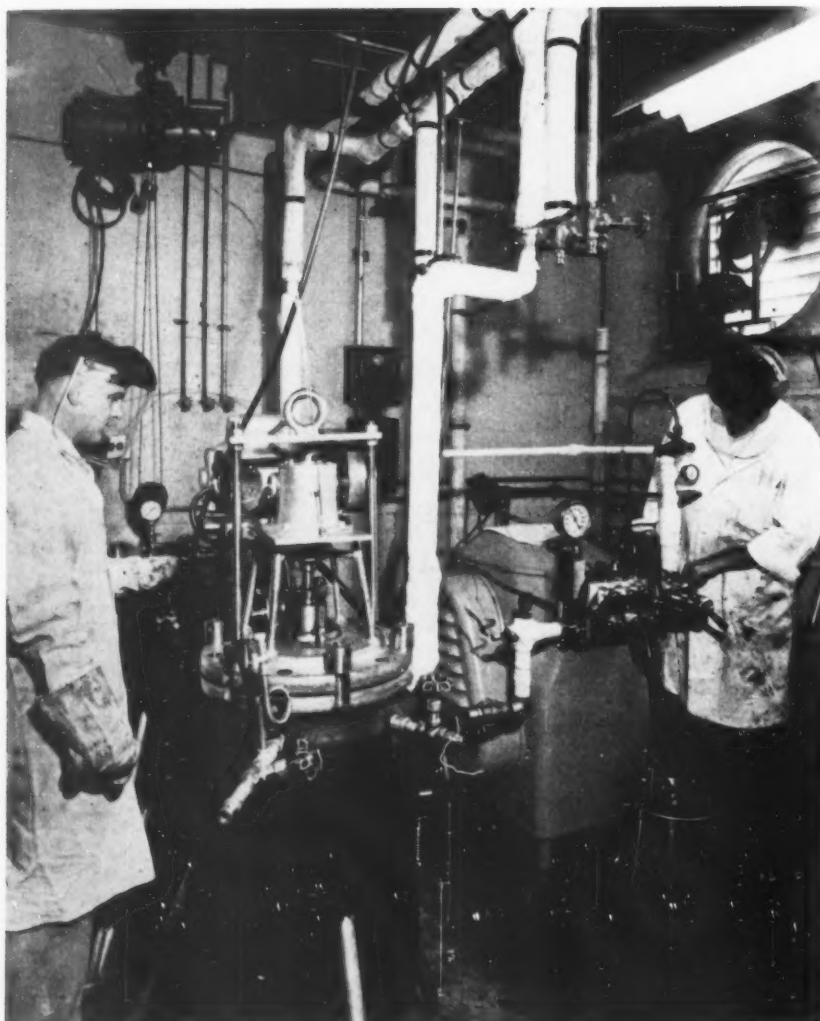
NEW
MEMBER



Attapulgus Minerals & Chemicals Corp. Joins

NLGI Welcomes New Associate Member

Grease Pilot Plant



Attapulgus' modern pilot plant for making multi-purpose Permagel greases is installed in the Camden, N. J., laboratories of the company. Here Attapulgus processes base oils from many major oil companies.

NO STRANGER to the petroleum field is Attapulgus Minerals & Chemicals Corporation, Philadelphia, Pa. For many years it and a predecessor organization, Attapulgus Clay Company, have been prominent factors in the mining and manufacture of various fuller's earth products used as adsorbents and refining media in the petroleum industry and as industrial floor adsorbents.

Attapulgus operates extensive fuller's earth mines at Attapulgus, Georgia, as well as research, development, process design and engineering laboratory facilities at Camden, N. J., Lakeland, Fla., Carlsbad, N. M., and Hibbing, Minn. General offices are at 210 West Washington Square, Philadelphia. L. R. Streander is president, and David E. Lilienthal, former chairman of the Atomic Energy Commission, is chairman of the board.

The latest of Attapulgus' contributions to a long record of service to petroleum industries has been the development of PERMAGEL, a new thickening agent for making multi-purpose greases. PERMAGEL is a pure, inorganic colloidal form of the mineral attapulgite for which Attapulgus claims the ability to gel a wide range of petroleum base oils and synthetic lubricants.

The company offers prospective users detailed technical information and samples of the material for laboratory evaluation. Attapulgus also makes available complete pilot plant facilities for evaluation work on base oils. The initial unit of a plant for production of PERMAGEL is now being completed, and the company expects to initiate commercial shipments in January 1954.

NLGI Company Representative

R. H. Hubbell, Jr., vice-president and manager of sales for Attapulugus Minerals & Chemicals Corporation, has a professional career of 21 years of considerable technical and sales experience.



R. H. Hubbell, Jr.

Mr. Hubbell was graduated from Massachusetts Institute of Technology in 1932, with a B.S. degree in chemical engineering. He joined Attapulugus Clay Company in the same year in the capacity of laboratory technician, and has since served in a number of important company positions. Chronologically, these are laboratory director of the company's Technical Division, assistant sales manager, administrative assistant to the president, and manager of the Technical Division. He assumed his present duties in 1946.

Mr. Hubbell is a member of the American Petroleum Institute and has written several papers on lube oil percolation.

NLGI Technical Committee Member

C. O. Martin handles sales and technical services activities in connection with PERMAGEL. A graduate of the University of Pennsylvania, from which he holds a degree in chemistry, Mr. Martin has been closely associated since 1948 with laboratory development and application work



C. O. Martin

on PERMAGEL, particularly in the lubricating grease field. With commercial production of PERMAGEL scheduled for the near future, Mr. Martin's considerable technical knowledge of the product and its applications should be very helpful to prospective users.

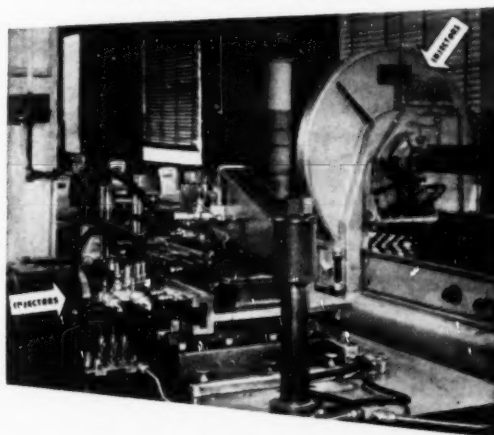


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W. T. Meinert Promoted By Emery Industries



Walter T. Meinert

Emery Industries, Inc., announces the appointment of Walter T. Meinert to the position of assistant director of the development and service department. He has been a member of this department for the past four years, during which time he has been active in both the development of new products and technical service activities concerning Emery's line of fatty acids, plasticizers and textile products.

Mr. Meinert received a B.S. degree in chemistry from St. Ambrose College, Davenport, Iowa, and an M.S. degree from The Institute of Textile Technology, Charlottesville, Va.

Currently he is a member of the American Chemical Society, American Association of Textile Chemists and Colorists, and the American Oil Chemists Society.

Estes Joins Emery Research

Dr. R. G. Kadesch, research director, announces the appointment of Dr. R. Ray Estes to the research staff of Emery Industries, Inc. Dr. Estes will be connected with the new chemicals department under the immediate direction of Dr. C. Goebels.

Dr. Estes comes to Emery from the University of Kentucky where he has been assistant professor in chemistry

and director of research for the past seven years. Prior to that, he was associated with Armour Laboratories, University of Texas and Emory University. After receiving a B.S. Degree in chemistry at Berry College in Alabama, Dr. Estes obtained his M.S. Degree at Emory University and his Ph.D. in chemistry at the University of Texas. During the past several years, he has been an active member of the American Chemical Society, Sigma Xi, and Phi Lambda Upsilon.

OIIC Elects Brown As National Chairman

Stewart Brown, public relations manager of Standard Oil Company of California, San Francisco, has been elected national chairman of the Oil Industry Information Committee for 1954.

Mr. Brown, on January 1, will succeed Stanton K. Smith, president of Smith Oil & Refining Co., Rockford, Ill. He was elected unanimously at a recent meeting of the national committee, which directs the industry-wide public relations program sponsored by the American Petroleum Institute.

Vice-chairmen elected are:

Richard Rollins, secretary, The Atlantic Refining Co., Philadelphia, Pa.;

W. R. Huber, general manager of retail sales, Gulf Oil Corp., Pittsburgh, Pa.;

Douglas Campbell, public relations director, The Pure Oil Company, Chicago, Ill.;

A. D. Eubank, division manager, Quaker State Oil & Refining Co., Kansas City.

John S. Cooke, of the American Petroleum Institute, New York, was re-elected secretary.

Concurrent with announcement of Mr. Brown's election, the committee also announced that one more meeting will be held this year, and four next year, as follows:

December 7-9, 1953, New York;

March 8-10, 1954, Houston Texas;

June 7-9, 1954, Chicago or Detroit, Mich.;

September 8-10, Chicago;

December 8-10, New York.

W. E. Bridges Transferred By Swift & Company



W. E. Bridges

W. E. Bridges has been transferred to Swift & Company's industrial oil department with headquarters at Hammond, Ind. He has been assigned to the sales staff and also will have charge of the company's advertising campaign.

Mr. Bridges is a graduate of Washington University, St. Louis, receiving his degree in chemical engineering in 1949. Shortly after his graduation he joined the sales staff of Swift's industrial oil department, filling sales assignments in the East and Midwest. For the last two years he has been industrial oil sales representative in the Southwest, with headquarters in St. Louis.

U. S. Steel Extends Parsons' Responsibilities

Responsibilities of Lewis M. Parsons, vice-president, United States Steel Corporation, Washington, D. C., have been extended to include the Philadelphia area, it was announced by David F. Austin, executive vice-president-commercial.

In commenting on Mr. Parsons' appointment, Mr. Austin said, "This new post is being created by United States Steel because of the increasing im-

portance of Philadelphia as a steel-producing and consuming area."

Mr. Parsons will maintain offices in both cities.

Born in Philadelphia on January 9, 1898, Mr. Parsons attended William Penn Charter Preparatory School and the University of Pennsylvania. During World War I he served in the Navy, first on a destroyer and later as one of the first pilots in the flying corps. While in the service he attended the Massachusetts Institute of Technology.

At the end of his war service in 1919, he became associated with the Bethlehem Steel Company, and in 1936 he was made manager of sales in Philadelphia for that company. In 1938, Mr. Parsons became vice-president and general manager of sales as well as a director and executive committee member of Jones and Laughlin Steel Company in Pittsburgh. In 1945, he joined United States Steel as assistant to vice-president-sales in Washington.

During World War II Mr. Parsons was a member of the general advisory committee, steel division, of the War Production Board.

Jones & Laughlin Adds C. K. Hubbard to Staff

Chauncey K. Hubbard, formerly vice-president of Rockwell Manufacturing Company, has been named assistant to the general manager of the Container Division of Jones & Laughlin Steel Corporation, it was announced by A. A. Archibald, director—special products and services for Jones & Laughlin.

Mr. Hubbard will make his headquarters in the New York offices of the Container Division, 405 Lexington Avenue. This division, which manufactures a variety of steel containers including drums, pails and galvanized ware, operates eight manufacturing plants throughout the United States.

Mr. Hubbard was with Rockwell Manufacturing Company from 1936 to 1953 and with Mellon National Bank from 1929 to 1936.

He is a graduate of Yale University, the Hotchkiss School and the Fessenden School. He served with the U. S. Naval Reserve from 1942 to 1945.

R. A. Reinke Promoted To Technical Coordinator



R. A. Reinke

R. A. Reinke, superintendent of the Continental Oil Black Co., at Westlake, La., since 1951, has been promoted to technical coordinator of Continental Carbon Co., with headquarters at 1400 West 10th Ave., Amarillo, Texas. He will direct the company's Amarillo control and technical service laboratory and function as company liaison officer between plant production and sales.

Mr. Reinke was graduated in 1939 by University of Chicago with a degree of B.S. in chemistry and pursued graduate work there. He became a chemist at Continental's Sunray, Texas, plant in 1944 and successively occupied positions as assistant superintendent and superintendent of operations both for channel and furnace type units.

Van Atta Joins ASTM Staff

The American Society for Testing Materials has announced the appointment as special assistant, on the headquarters staff, of Fred F. Van Atta, recently manager, Building Div., Carolinas Branch, Associated General Contractors; and formerly acting secretary-treasurer of the American Concrete Institute and editor of the ACI Journal. For the immediate future, Mr. Van Atta will concentrate his

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work on coordinating and extending the ASTM developmental and promotional activities, but special assignments will be made from time to time. In this work he is reporting directly to ASTM Executive Secretary R. J. Painter.

A graduate of Michigan State College, in civil engineering, and with service in the Coast and Geodetic Survey; Tennessee Valley Authority; and for several years in the Corps of Engineers, U. S. Army, Mr. Van Atta brings excellent experience to help advance the work of ASTM—involving standards and research in materials.

Lubrizol Promotes Baird, Two Others in Sales Division

Announcement of three promotions in the sales division of The Lubrizol Corporation of Cleveland was made recently by F. Alex Nason, vice-president in charge of marketing.

John H. Baird has been promoted to assistant to the vice-presidents in charge of marketing and sales in the Cleveland office. William W. Schafer has been made Lubrizol's midcontinent sales representative at Tulsa, Okla.,

and Charles B. Collins has been made sales representative for the east central areas of the United States and Canada.

Mr. Baird, who is 44 years old, was born in McKeesport, Pa. He graduated from Case Institute of Technology in 1932, with a degree in mechanical engineering and has been with Lubrizol since 1933. For the past 14 years, he has been in charge of sales for the company's midcontinent division in Tulsa, Okla. Mr. Baird is past chairman of the midcontinent section of the Society of Automotive Engineers, a member of the American Petroleum Institute and company representative to the National Lubricating Grease Institute.

Mr. Schafer, a Cleveland, is 28 years old, a graduate of Rollins College, Winter Park, Fla., with a B.S. degree. During World War II, he served with the Infantry. He came to Lubrizol in 1950.

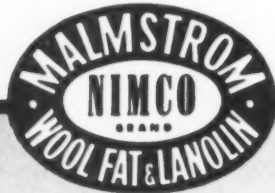
Mr. Collins is 27 years old, was born in Kansas City, Mo. He attended Princeton University where he studied aeronautical engineering. He was with the Air Force during World War II and came to Lubrizol in 1949.

Socony-Vacuum Elects Siegel As Director and Executive —Middle East Affairs

Robert Siegel, who started with the company as an office boy in 1920, and has been associated with foreign oil producing activities during most of his career, was elected a director and executive in charge of Middle East affairs of Socony-Vacuum Oil Company, Inc. He fills a vacancy on the board of directors left by the death of Charles L. Harding.

In November 1951, he became president of Socony-Vacuum Overseas Supply Company with headquarters at Fort Lee, N. J. He has resigned that position to accept his new responsibilities. The board of Socony-Vacuum Overseas Supply Company has elected A. C. Ingraham as Mr. Siegel's successor.

Mr. Siegel is a director of the Y.M.C.A. in Montclair, in which capacity he is in charge of its world service campaign. He is a member of the American Institute of Mining and Metallurgical Engineers and is an associate member of the Institute of Radio Engineers.



Lubricating grease manufacturers know that top value and peak performance go hand-in-hand. That's why Malmstrom's NIMCO brands are specified. N. I. Malmstrom — largest processors of wool fat and lanolin products — produce quality components for grease production.

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Moisture	2% max.
Unsaponifiable (Wool Grease Alcohols)	6% max.
Saponifiable	94%
Free Fatty Acid (as oleic)	55-60%
Actual Free Fatty Acid Content	90%
Saponification No.	120-130
Free Inorganic Acid	0.2% max.
Iodine Value	20-40
Apparent Solidification Point (titre)	Approx. 44° C.
Softening Point	45-48° C.
% Sulfur	No corrosive sulfur

A.O.C.S. Methods



Industry NEWS

Shell Issues Booklet On Machine Tools And Their Lubrication

An interesting history of the development of machine tools, a simple explanation of their mechanical aspects and an analysis of the role of lubricants in their maintenance and operation are contained in a new illustrated booklet, "Machine Tools and Their Lubrication," which has just been issued by Shell Oil Company.

It is the second number in the Volume II series of the Panorama of Lubrication booklets published by Shell, and was written to be of interest both to readers unfamiliar with machine tools and to experienced machinists.

In making the booklet available free to technical institutions and interested persons in the machine tool and other heavy industries, Shell stresses that it is not a manual on machine tool lubrication. Instead it is a comprehensive discussion of the fundamental factors found in the construction, operation and maintenance of modern machine tools.

Three years in preparation, the booklet required the collation and editing of material from hundreds of sources. It contains many photographs and drawings in color to depict graphically the functions of the various components of machine tools and their lubricants.

The booklet begins with an account of the development of machine tools. Then it shows how power is controlled and force is directed to shape metal by cutting and chipping, analyzes the factors that contribute to friction and wear and describes the roles of lubricants.

In the latter connection, the booklet explains that perhaps the most important function of the lubricant is as an actual mechanical part of a machine tool—acting as a fluid shim, filling the clearance spaces that have to be allowed between moving parts—thus making possible the amazing precision needed to turn out work accurate to a ten-thousandth of an inch, and even finer.

In the next section, specific classes of machine tools are described; lathes, milling machines, grinders; drills,

broaches and tapping machines; planers, shapers and slotters and contour cutting machines.

Hydraulically actuated devices for operating and controlling certain actions of machine tools, which have become increasingly important in recent years, are discussed separately. The booklet concludes with a section on the various types of lubricants and their application.

Copies of the booklet may be obtained by writing Shell Oil Company, 50 West 50th Street, New York 20, N. Y., or 100 Bush Street, San Francisco, Calif.

Texaco Designed Train Permits Uniform Burning

An automatic microcombustion train for carbon and hydrogen determinations, which permits uniform burning of a sample and frees the operator for other laboratory work, has been designed and built by the Beacon Laboratories of The Texas Company.

Chemist Ervin Stehr designed the apparatus which embodies an automatic mechanism to advance the small electric furnace at a rate determined by the progress of the combustion. The design of the train also provides for the adjustment of different units in the system and permits setting up various determinations with the same basic equipment.

The development of the automatic train has enabled Texaco, a pioneer in the use of micro techniques, to step up its volume of analyses, and has added to the efficiency of the microchemical procedures carried out at the main research center of The Texas Company.

The Beacon Laboratories first applied microchemical methods about 18 years ago. During its early work with micro samples, Texaco had very little equipment and none of the trains it uses today. Now micro methods are used to determine all the elements in organic compounds.

Besides providing a valuable research tool in product development, microchemistry has added significantly to the company's technical services, according to research officials.

API Action Will Affect Thousands of Contracts

In an action that will affect thousands of contracts, the American Petroleum Institute announced that it is withdrawing its approval of the National Standard Petroleum Oil Tables issued in 1936.

The institute said that the American Society for Testing Materials and the Institute of Petroleum have published a volume of recalculated and extended Petroleum Measurement Tables, and that it is endorsing these as the new national standards.

Approval of the change was voted by the executive committee of the API board of directors at a meeting in White Sulphur Springs, W. Va. The action was taken at this time to give the industry as much advance notice as possible for substitution of the tables in regulations, tariffs and contracts.

The full text of the API resolution states:

"Whereas, The National Standard Petroleum Oil Tables (National Bureau of Standards Circular C410, March 4, 1936) bears statement of its approval by the American Petroleum Institute and the American Society for Testing Materials, and

"Whereas, The American Society for Testing Materials in cooperation with The Institute of Petroleum has published a volume of recalculated and extended ASTM-IP Petroleum Measurement Tables (ASTM Designation: D1250, IP Designation: 200) which has been recommended for approval in lieu of National Standard Petroleum Oil Tables, and

"Whereas, the substitution of the ASTM-IP tables for the NBS-C410 tables in regulations, tariffs and contracts will require a substantial period of time,

"Now, therefore be it resolved by the Executive Committee of the Board of Directors that the American Petroleum Institute shall withdraw its approval of The National Standard Petroleum Oil Tables (C410) and shall approve ASTM-IP Petroleum Measurement Tables (ASTM Designation:

D1250, IP Designation: 200) and shall recommend that official regulations and contracts should be changed accordingly on January 1, 1954, or as soon as practicable thereafter, with the understanding that the ASTM-IP Petroleum Measurement Tables shall become effective on January 1, 1954 in all cases where official regulations or contracts do not provide otherwise."

Alemite Illustrates Automatic Lubrication

How automatically to lubricate entire conveyor lines—trolley wheels, chains, drives, carriers and rollers—without stopping the line, thus eliminating shutdowns for lubrication, work spoilage and hazards of lubrication is illustrated in a new catalog sheet distributed by the Alemite Division of Stewart-Warner Corporation.

The utilization of Alemite's "big three" in industrial lubrication—conveyor trolley wheel lubricator, Accumeter centralized lubrication and oil mist all fully automatic—helps insure

economic and dependable lubrication of entire lines.

The conveyor trolley wheel lubricator goes to work at the flick of a switch and lubricates every wheel on both sides of the track, delivering an exact, measured amount of lubricant to each wheel. One filling of the container provides 25,600 shots of oil or grease, enough for approximately four miles of track.

Alemite's Accumeter centralized lubrication system protects main drives and motors by delivering at selected time intervals a measured filtered shot of fresh lubricant, flushing out dirty, worn grease. The Accumeter valves are located on or near bearings of main drives, motors or other assemblies and are fed lubricant through tubing from an inlet block or pump located conveniently at floor level.

Chains, pendants and other conveyor parts—formerly difficult to lubricate—can now have time-saving, fully automatic lubrication with Alemite Oil Mist. This system atomizes oil into mist—distributes it through tubing to bearings—bathes all surfaces with a cool film of clean oil.

It goes wherever needed—to groups of bearings, slides, chains or gears. The oil mist system reduces oil consumption up to 90 per cent, while at the same time the air flow through the bearings prevents infiltration of dirt.

Baker Adds Sales Office

On September 1st, The Baker Castor Oil Company opened a new sales office at 640 Gilman Street, Berkeley, Calif. In making the announcement, H. H. Fritts, vice-president of the company, stated that Marvin C. Rasmussen would be in charge and would service all accounts in the bay area from the new office. For two years prior to joining Baker he was employed as a technical service engineer in the Research and Development Division of S. C. Johnson & Son, Inc. Mr. Rasmussen is a member of the Golden Gate Production Club and of the Northern California Rubber Group.

Warehouse stocks of Baker products will be maintained at Hawxhurst & Company, Second and Gilman Streets, Berkeley 10, Calif. and at W. R. Grace & Co., Second and Berry Streets, San Francisco.

Emery Industries Expands Dimer Acid Production

To meet the rapidly increasing demand for dimer acid in a variety of uses, Emery Industries, Inc., Cincinnati, announces an expansion in facilities for producing this unusual long-chain dibasic acid.

At the same time, improvements in processing methods will produce a lighter colored product. According to Emery's evaluation against current production, all other characteristics of the improved product will remain unchanged.

According to Robert F. Brown, sales manager of Emery's Chemical Division, the new production will be designated "Empol 1022 Polymerized Fatty Acid"—to avoid possible confusion with other unrelated "dimers."

Full-scale production of Empol 1022 is anticipated for early in December. Shortly thereafter, Empol 1022 will replace completely the present Emery 955 Dimer Acid.

Limited quantities of Empol 1022 are now available for experimental work.

General Mills Moves A Sales Department

The chemical products sales department of General Mills' Chemical Division moved from Minneapolis, Minn., to Kankakee, Ill., it was announced by Sewall D. Andrews, Jr., general manager of the division.

The move is expected to provide more efficient and accurate customer sales service, Mr. Andrews said.

Manager of Kankakee operations is W. B. Brown. Abner C. Hopkins, Jr., is director of chemical sales. Mr. Hopkins will be assisted by M. S. Herban, S. J. Murphy and W. S. Mitchell, who have been appointed managers of technical sales and service for Eastern, Central and Western districts respectively.

Purchase of all raw materials will be handled at the new office, under the direction of L. C. Young. This is designed to further consolidate total plant activity and improve service to customers, Andrews pointed out. Inquiries relating to the sale of chemical products, however, Mr. Andrews said, should continue to be directed to chemical division sales representa-

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Whether you're making black oil greases or clear lubricants, you'll find the use of Metasap Aluminum Stearates will solve your manufacturing problems, cut costs, give you a better finished product. Check these Metasap grease bases for economical production of lubricants with any desired body:

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METASAP GM—gives a medium heavy gel where smoothness is of prime importance.

METAVIS 540—can be used with wide range of mineral oils; produces semifluid, adhesive-type lubricant known as castor machine oil; highly economical.

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6. more economical

Samples are available for experimental work. Our research and technical staff will be glad to help you select the correct base for any given oil, or achieve any desired effect in a finished grease through use of proper soap mixtures.

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regular products, we will work with you in developing special sulfonates of calcium, barium and other metals.



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tives who maintain offices in all principal cities.

General Mills' chemical plant at Kankakee produces a complete line of fractionally distilled fatty acids, modified fatty acids and oils, and a series of polyamide resin materials. These products are utilized by the paint and varnish, soap, rubber, mining, cosmetic, paper and other industries, as basic raw materials. In addition, the Kankakee plant manufactures fatty nitriles and amines.

Sales of refined soybean oil and soybean oil meal products, produced at the company's plants in Belmond, Iowa, and Rossford, Ohio, will continue to be handled by the Minneapolis headquarters office.

Nickerson Emphasizes Human Values in Talk

"The job of management is in the most fundamental sense the job of developing people," Albert L. Nickerson, vice-president and director in charge of foreign trade of Socony-Vacuum Oil Company, Inc., said here in a talk to a conference of businessmen and educators. The meeting, sponsored by the College English Association and held at the Corning Glass Center, has as its theme "Business and the Liberal Arts: An Exchange."

Management, Mr. Nickerson continued, must utilize its investment in manpower as fully as it must utilize its investment in physical facilities and processes.

"Any policy based on laissez-faire survival of the fittest is," he declared, "by any measure inadequate and therefore dangerous." Mr. Nickerson, speaking on "Business and Human Values" on the second day of the three-day institute, was the feature speaker at a panel moderated by William G. Caples, vice-president of Inland Steel Company.

"The overriding problems of business in the years to come," Mr. Nickerson asserted, "will be those centering around human relations and human values. We must continue to raise the standard of living in a world whose population is growing prodigiously and, by means of this standard, to preserve and enlarge further the freedom of the individual."

The speaker declared that the world now can have, for the first time

in history, a high standard of culture based not on exploitation of human beings, but rather on exploitation of machines and the production of mechanical horsepower, with a consequent elevation of human dignity. This and other of our achievements, he added, are those of "free men in a free society, increasingly enlightened by a rapidly developing free educational system and able to attain our individual capacities in a free-enterprise economy."

"No business can or should long endure that does not make a profit," he asserted. "Business losses are a free society's thumbs-down on companies that fail to earn the right to survive. In the long run, the public pays for inefficiencies and uneconomic practices. It is only the profit system which can effectively encourage efficient and economic practices and eliminate inefficient and uneconomic practices."

Mr. Nickerson made a plea for humanistic education for students majoring in technical fields as well as for those studying liberal arts.

"Our business system, indeed our whole scheme of contemporary American life," he said, "require the education of young men and women of moral stamina who can think and who can discriminate among values. Science's dimensions seldom, if ever, attain to the level of moral values. If we receive from the schools and colleges people whose experience is truncated by a lack in these wider dimensions, we may end up with businesses staffed by men inadequate to deal with the social and economic problems with which they are sure to be faced."

ASTM Offers Reprints

American Society for Testing Materials announces the availability of reprinted copies of the "Review of ASTM Research," as published in the December 1952 and January and February 1953 ASTM Bulletins.

This material, prepared by the ASTM Administrative Committee on Research, summarizes the work of the various technical committees of the society as of May 1953.

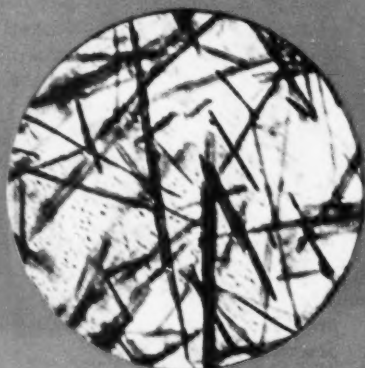
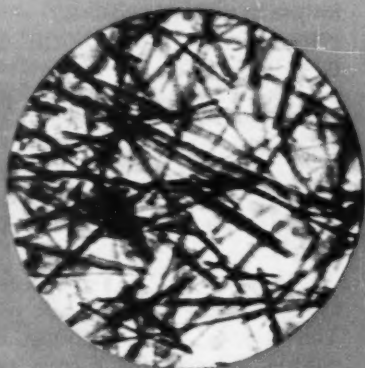
Copies of this 22-page pamphlet are available, without charge, at ASTM Headquarters, 1916 Race Street, Philadelphia 3, Pa.

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Grease-makers, this good news is about Permagel—Attapulgius' new thickening agent for making high quality, multi-purpose greases. The constant uniformity of Permagel's pure, inorganic, insoluble needle-like particles means that in grease manufacture *uniform* gel networks can be produced, day-in, day-out. What's more, ideal particle size and shape of Permagel are inherent characteristics—do not have to be made by costly controlled processing.

Whether your grease production method is continuous or batch, Permagel offers *you* grease reproducibility. You'll do well to use Permagel for many other reasons, too.

For example . . . its needle-like particles give greases which remain stable under a wide variety of operating conditions . . . Permagel greases are unusually tough in high shear service, have excellent low temperature pumpability, resist washout by water and show outstanding bearing performance.

Put these many advantages of Permagel to work in *your* grease products! We'll be glad to send you a free sample of Permagel for evaluation, together with our new information-filled Bulletin P-53. We're also prepared to process samples of your base oils in our modern grease pilot plant, should you desire. May we be of service?

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foundry partings
greases
leather oils
lube oil additives
lubricants
monoglycerides
paper coatings
penetrating oils
pharmaceuticals
plastics
quenching oils
resins
rubber compounding
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Global Grease Developed By The Texas Company

A "global grease" which performs effectively in desert or arctic operations has been developed by The Texas Company research laboratories for use in military vehicles.

Known as Texaco All Temp Grease, the new lubricant contributes to the solution of a difficult logistics problem. This problem can best be demonstrated by citing the case of a vehicle which might have to be flown from a desert military post to an installation where sub-zero temperatures are normal.

In times past it has been necessary to completely relubricate the vehicle. This meant ordering, storing, transporting and applying a large variety of greases. Texaco All Temp helps to eliminate this logistics problem with a lubricant which efficiently lubricates vehicle bearings in ambient temperatures ranging from minus 65 degrees (F) to plus 125 degrees (F).

This new grease possesses the following characteristics: good low temperature operation, excellent shear stability which prevents leakage in tropic heat, high oxidation resistance which imparts long life, good rust and corrosion protection for metal parts, and the capacity to perform even when contaminated with water.

'Ten Trails to Sales'

All of the ten trails to sales, followed by successful salesmen, are interestingly and clearly mapped in a newly published book by that name—*Ten Trails to Sales*—just announced by Lloyd R. Wolfe, Publisher.

Authored by Fred De Armond, nationally known business consultant and famous for his many books and magazine articles on selling and sales training, *Ten Trails to Sales* is the summation of his broad and analytical background—it contains the theories of profitable selling, as well as time-tested practical applications.

Says Mr. De Armond,

"A sale is probably half made before you even stand in front of the buyer . . . For that reason, four of these Ten Trails to Sales relate entirely to preparation and the other six to those things which good salesmen do and say—in actual landing of the order . . ."

Of the three requirements for success in selling—a good product, seeing enough buyers and asking for the order—Mr. De Armond has concluded that “asking buyers in the right way to buy what you are selling, adding head work to leg work” is most important.

Thus, Mr. De Armond, an experienced former salesman and sales manager, forcefully charts a successful selling technique. He guides the salesman along the successive trails—pointing out the rough spots, new twists and angles; the peaks and valleys—but with an eye constantly on the ultimate objective—*getting the prospect's name on the dotted line.*

Ten Trails to Sales is a proven course for the “tenderfoot” and an indispensable refresher for the “old-timer.” No matter what his line—merchandise or service, tangible or intangible—every man expected to do a selling job can learn from Mr. De Armond's book. Its pages are filled with valuable pointers, case histories, applied psychology and practical methods—simply, forcefully presented and interestingly illustrated.

Ten Trails to Sales will appeal as a reference to salesmen and executives directly or remotely in contact with customers and prospects.

Technical Bulletin Offered By Monsanto Chemical Co.

Procedures for obtaining a variety of surface active end products from the sulfonation of alkyl benzene are contained in a technical bulletin just published by the Phosphate Division of Monsanto Chemical Company.

Monsanto's alkyl benzene is specifically produced for use as an intermediate for a variety of concentrations of alkyl aryl sulfonate type detergents and wetting agents.

Batch type manufacturing procedures are outlined for producing active sulfonates ranging from 40 per cent to as high as 88 per cent active. The bulletin points out that these alkyl aryl sulfonates produced from Monsanto's alkyl benzene can be modified with inorganic phosphates to obtain desired end-property results.

As a further aid to the processor in this field, the bulletin outlines analytical procedures for the usual general property tests to determine color, water content, per cent of sodium sulfate and per cent of active content.

Copies of the technical bulletin, as well as more detailed information on either batch type or continuous processing of alkyl benzene, can be obtained from Phosphate Division, Monsanto Chemical Company, St. Louis 4, Mo.

Continental Can Consolidates Betnar and Shellmar

Continental Can Company's two recent acquisitions, the Benjamin C. Betnar Company and Shellmar Products Corp., have been consolidated into the company's new Shellmar Betnar Flexible Packaging Division.

Benjamin C. Betnar Jr., will be in charge of operations for the new division, with headquarters in Mt. Vernon, Ohio, former main office of Shellmar.



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come proven lubricants
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FUTURE MEETINGS of the Industry

NOVEMBER, 1953

- 29- American Society of Mechanical Engineers (annual meeting), Statler Hotel, New York, N.Y.
- 30- Twenty-fourth Exposition of Dec. 5 Chemical Industries, Commercial Museum & Convention Hall, Philadelphia, Pa.

DECEMBER, 1953

- 7-9 Oil Industry Information Committee, Waldorf-Astoria, New York, N. Y.
- 13-16 American Inst. of Chemical Engineers (annual meeting), Jefferson Hotel, St. Louis, Mo.

JANUARY, 1954

- 11-15 Society of Automotive Engineers (annual meeting and engineering display), Sheraton-Cadillac and Statler Hotels, Detroit, Mich.

FEBRUARY, 1954

- 8-10 Missouri Petroleum Assn. (annual convention), Chase Hotel, St. Louis, Mo.
- 15-17 American Petroleum Institute (Lubrication Committee), Sheraton-Cadillac Hotel, Detroit, Mich.
- 17-18 Iowa Independent Oil Jobbers Assn., Fort Des Moines Hotel, Des Moines, Iowa.

MARCH, 1954

- 1-5 American Society for Testing Materials (spring meeting), Shoreham Hotel, Washington, D. C.
- 2-4 Society of Automotive Engineers (national passenger car, body, and materials meeting), Hotel Statler, Detroit, Michigan.
- 3-5 American Petroleum Institute (Division of Production, Southwestern District), Rice Hotel, Houston, Tex.
- 8-10 American Inst. of Chemical Engineers, Statler Hotel, Washington, D. C.
- 8-10 Texas Oil Jobbers Assn. (annual convention exhibit), Baker Hotel, Dallas, Texas.

- 16-18 Ohio Petroleum Marketers Assn. (annual convention and marketing exposition), Desler-Hilton Hotel, Columbus, Ohio.

- 17-19 American Petroleum Institute (Division of Production, Mid-Continent District), Skirvin Hotel, Oklahoma City, Okla.

Lubricate for Safety Every 1,000 Miles



APRIL, 1954

- 5-7 American Society of Lubrication Engineers, Netherland-Plaza Hotel, Cincinnati, Ohio.
- 8-9 American Petroleum Institute (division of production, Rocky Mountain district), Townsend Hotel, Casper, Wyo.
- 12-15 Society of Automotive Engineers (national aeronautical meeting, aircraft engineering display, and aircraft production forum), Hotel Statler, New York, N. Y.
- 14-16 National Petroleum Assn. (51st semi-annual meeting), Cleveland Hotel, Cleveland, Ohio.

MAY, 1954

- 2-4 Independent Petroleum Assn. of America (midyear meeting), Cosmopolitan Hotel, Denver, Colo.
- 3-5 American Petroleum Institute (Lubrication Committee), Skytop Lodge, Skytop, Pa.
- 3-7 American Petroleum Institute (safety & fire protection committees, midyear meeting), Chase-Park Plaza, St. Louis, Mo.
- 6-7 American Petroleum Institute (division of production, Pacific Coast district), Statler Hotel, Los Angeles, Calif.
- 10-12 American Petroleum Institute (Division of Transportation, Products Pipe Line Conference), Warwick Hotel, Philadelphia, Pa.
- 10-13 American Petroleum Institute (Division of Refining, Mid-year Meeting), Rice Hotel, Houston, Texas.
- 16-19 American Inst. of Chemical Engineers, Springfield, Mass.
- 17-18 Empire State Petroleum Assn., Roosevelt Hotel, New York, N. Y.
- 17-19 American Petroleum Institute (Division of Marketing, Mid-year Meeting), Cosmopolitan Hotel, Denver, Colo.
- 24-25 Packaging Institute (petroleum packaging committee), Cleveland, Ohio.
- 31- American Petroleum Institute June 5 (division of production, mid-year committee conference), San Francisco, Calif.

JUNE, 1954

- 6-11 Society of Automotive Engineers (summer meeting), The Ambassador and Ritz-Carlton Hotels, Atlantic City, N. J.
- 13-18 American Society for Testing Materials (annual meeting and exhibits), Sherman Hotel, Chicago, Ill.
- 17-19 American Petroleum Institute (Division of Production, Eastern District), Greenbrier Hotel, White Sulphur Springs, W. Va.



PLAN AHEAD

The end of construction and the beginning of full production are near at hand. Quantities of lithium hydroxide are now being shipped from Foote's new lithium chemical plant at Sunbright, Va.

With the realization that Sunbright is approaching full production, you can now plan ahead in terms of Foote lithium.

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phase 4:

Foote's new lithium chemical plant

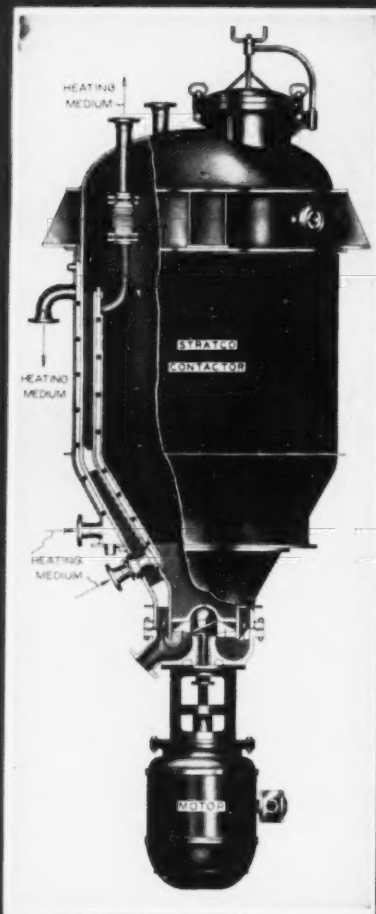
phase 3 — Pilot plant operations of an exclusive lithium process developed by Foote

phase 2 — Kings Mountain, N. C. — Mining largest known deposits of spodumene.

phase 1 — Continuing Foote research finding new and improved uses for lithium chemicals



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